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MARCO PAUL'S
TRAVELS AND ADVENTURES
IN THE
PURSUIT OF KNOWLEDGE.

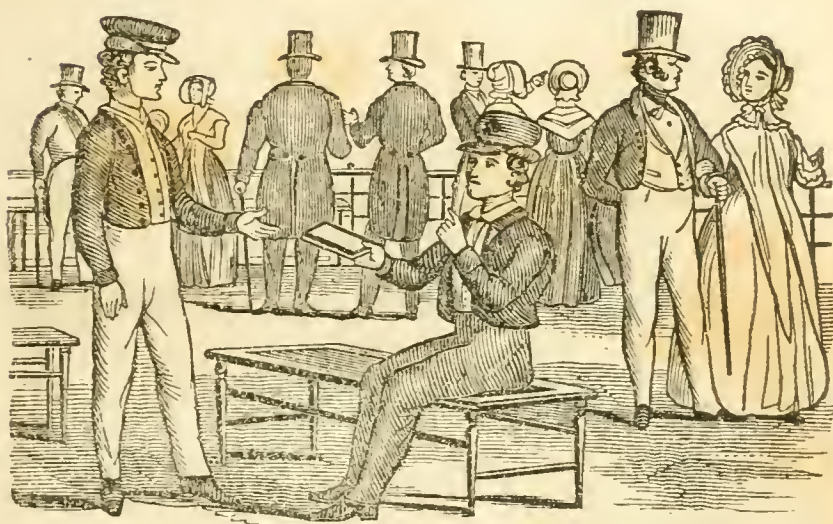




"Marco saw a man and his boy going out to the barn, on a raft made of the barn doors."—See page 34.

MARCO PAUL'S
ADVENTURES
IN PURSUIT OF KNOWLEDGE,

SPRINGFIELD ARMORY.



Marco and the deaf and dumb boy.—See p. 23.

BY THE AUTHOR OF
ROLLO, JONAS, AND LUCY BOOKS.

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P R E F A C E .

THE design of the series of volumes, which it is intended to issue under the general title of MARCO PAUL'S ADVENTURES IN THE PURSUIT OF KNOWLEDGE, is not merely to entertain the reader with a narrative of juvenile adventures, but also to communicate, in connexion with them, as extensive and varied information as possible, in respect to the geography, the scenery, the customs and the institutions of this country, as they present themselves to the observation of the little traveller, who makes his excursions under the guidance of an intelligent and well-informed companion, qualified to assist him in the acquisition of knowledge and in the formation of character. The author will endeavor to enliven his narrative, and to infuse into it elements of a salutary moral influence, by means of personal incidents befalling the actors in the story. These incidents are, of course, imaginary—but the reader may rely upon the strict and exact truth and fidelity of all the descriptions of places, institutions and scenes, which are brought before his mind in the progress of the narrative. Thus, though the author hopes that the readers, who may honor these volumes with their perusal, will be amused and interested by them, his design throughout will be to instruct rather than to entertain.

S.M.T.I.



MARCO PAUL AT THE SPRINGFIELD ARMORY.

CHAPTER I.

THE WRONG BOAT.

IT was by a somewhat singular accident that Marco Paul had an opportunity to pay a visit to the great armory at Springfield. The circumstances were these.

On one occasion, while he was under his cousin Forester's care, they were going from New York city, to Forester's residence in Vermont. Marco wanted his cousin to allow him to choose the route.

"Very well," said Forester, "I have no objection. You may not only choose the route, but take the charge and direction of the whole journey."

"How do you mean?" asked Marco.

"Why, we will suppose," said Forester, "that I am an infirm old gentleman, and you undertake to conduct me safely to Vermont. You may choose the route, and let me know when I must be ready. Then you shall call the carriage, and

take me to the boat, and engage our berths, and do everything which a gentleman does for a lady in such a case."

"Well," said Marco, "I should like that very much."

In fact, Marco was very much pleased with the idea of exercising a little power. So he got a travelling map of New England, spread it upon a table, and began to study the features of the country, with reference to the different routes. There were two routes, which principally attracted his attention, which the reader will understand very distinctly by consulting a map. The first was, to go up the North river in the Troy boat, thence by rail-road to the southern end of Lake George, thence by steamboat along the lakes George and Champlain to Burlington, and from Burlington by stage, across the country, to the town where Forester's father lived.

The other route was by the way of Boston. Marco liked to go to Boston very much. He thought that he should like very well to go and spend a week at Boston, and then to go across the country by rail-road and stage. He hesitated a little, however, whether it would come within the limits of the power which Forester had entrusted him with, to spend a week in Boston. While doubting on this subject, he reflected that there would be the greatest variety of travelling on the North river route. He therefore finally decided upon that.

Then came another question to be decided, and that was, whether to take the day or the night boat up the North river. There is one steamboat which leaves New York for Albany and Troy every morning, and another every evening, so that one goes through by day, and the other by night. Marco decided in favor of the day boat, in order that he might see the scenery. This was not, in fact, a very wise decision, for the whole of a long summer's day is too long a time to spend in looking at scenery, however beautiful it may be, and the passengers who take the day boats for this purpose, generally become very tired of the pleasure before night. Whereas, in taking one of the night boats, some of which leave New York an hour or two before sunset, there are four or five hours before bed-time, during which the river scenery can be enjoyed, varied too, as it is at this time, by the changing light of sunset and evening, and perhaps, at last, clothed in the wild and solemn beauty which is shed over such a scene by moonlight, or the still fainter illumination of the stars. Thus a night passage is far more favorable for really enjoying the scenery of the Hudson, than a long and monotonous voyage, made under the full glare of the sun. Besides, at the time that Forster and Marco were making this journey, it was too early in the season to enjoy the scenery much. It was early in April, and though the grass was quite green in the Park at New York, yet the

Highlands and the Green Mountains were still covered with snow.

Marco, however, did not reflect on these things, and he decided upon the day passage. The boat was to go at seven o'clock. Marco learned this by a printed handbill, in large letters, which he saw posted up in the hall of the Waverly house, where his cousin always took a room when he came into New York. There were several of these handbills hanging on a sort of hook, one behind the other. It was the outer one which advertised the Albany boat.

"Now, cousin Forester," said Marco, the day before they were to go, "I will order a cab to come to our house at six o'clock, and will come down in it to the Waverly house and call for you."

"Very well," said Forester, "I will be ready at six."

Forester was ready at six, but it was nearly half past six when Marco arrived. Forester's trunks and baggage were in the hall, and as the cabman was carrying out one of the last articles he turned to Forester and said,

"What boat is it, sir, that you wish to go to?"

"I don't know," said Forester, turning to Marco. "Marco, he wants to know what boat we are going to."

"The boat?" said Marco, stopping to think. — "O, I'll tell you in a moment." So Marco stepped across the hall to the pillar where the notice was put up. He looked hastily upon the

outer handbill, and his eye caught the name "New York."

"The New York," said Marco.

"O——aye," said the cabman, "the New York."

"Stop a moment," said Marco, "and I will see where she lays."

"I know where she lays," said the cabman,— "she lays at Peck Slip."

Now it happened that since Marco had read the outer handbill the evening before, and found that it described a boat going to Albany, a man had come in and hung up another, advertising a boat to go to New Haven, which was the destination of the New York. Marco left the handbill immediately, when the cabman said he knew where the boat lay, and did not discover his mistake. Forester said nothing. He had an impression that Peck Slip was the place of departure for the Connecticut boats, and not for the North river boats; but as there was a route to Vermont through New Haven and Hartford, which was nearly as convenient for them as any other, he concluded to say nothing, but to let Marco manage the business which he had undertaken in his own way.

Marco thought, from the expression of his cousin's countenance when they got into the cab, that there was something the matter, or, at least, it appeared to him that Forester looked as if he had some secret in his thoughts, and he questioned him about it.

“You’ve got some secret, cousin Forester,—I know you have,” said he.

“Some secret?” repeated Forester; “what makes you suppose so?”

“Why, you look very queer,—you’ve got some present for me, I expect, from my mother, that you are going to give me when we get aboard the boat.”

Forester made no answer, and they rode on in silence. When they reached the slip where the boat lay, Marco was very busy in paying the cabman, and in seeing that the baggage was put safely on board. The first bell was rung. Many persons were coming and going over the plank which led from the pier to the boat. As soon as Marco had the baggage secured, he went up to the promenade deck, where he could be a little out of the bustle, and took a seat with Forester there. There were many ladies and gentlemen standing there, or seated on chairs and settees, under a large awning. It was a pleasant morning, and Forester anticipated a very pleasant voyage up the river.

Marco took his seat upon a settee, and watched the movements of the crowd upon the pier, and of the sailors on the guards of the boat, who were making preparations for casting off the lines. There was seated near him a boy somewhat older than he, who also seemed to be watching the movements around with great interest. Marco was just going towards him, with a design to enter

into conversation with him, when a young man appeared at the top of the stairs, leading up from the deck below, and beckoned to the boy to come to him, at the same time making some other sign which he did not understand. The boy immediately rose and went away.

In a short time, however, he returned and took his seat again. Marco had some hesitation about addressing him, but as the expression of the young stranger's face was intelligent and good-humored, he at length moved gradually towards him, and said,

“Do you know what time we shall get to Albany?”

The boy looked at Marco steadily when he spoke, with a pleasant expression of countenance, but instead of making any reply, he first put his finger to his ear, and then to his lips, and shook his head.

“What do you mean by that?” said Marco.

The boy said nothing, but gazed a moment longer in Marco's face, and then took out a very small slate from a breast pocket in his jacket, and began to write upon it. When he had finished writing, he handed the slate to Marco. It contained the words, “I cannot speak; I am deaf and dumb.”

“O,” said Marco, “I did not know that.” Then, instantly reflecting that it was vain to speak to him if he could not hear, Marco took the slate from his hands, and wrote upon it,

“I only asked you if you knew what time we should get to Albany.”

The boy read Marco's writing very slowly and carefully, and then shook his head and looked perplexed. He then took the pencil and wrote, “I do not know.”

By the same mode of communication, Marco then asked him what his name was. He wrote in reply, “Erskine.”

“Do you live at Albany?” wrote Marco next.

Erskine looked at the question a moment or two, apparently somewhat at a loss, and then he wrote,

“I do not know of Albany; I shall go to Hartford.”

It was now Marco's turn to be a little perplexed, through the singularity of Erskine's phraseology. After studying it a moment, he concluded that Erskine meant that he was going to Hartford, and the idea flashed across his mind that he might possibly have made some mistake, and have got into the wrong boat. So he turned suddenly to one of the hands that belonged on board the boat, who happened to be passing by just at that moment, and asked him,

“Is n't this boat going to Albany?”

“No,” replied the man, without stopping, “she is going to New Haven.”

“Then we've got into the wrong boat,” exclaimed Marco, in great trepidation. “Where's cousin Forester?”

He began to run about this way and that in pursuit of his cousin Forester. Forester had disappeared. He went down stairs to find him, and when he reached the lower deck, he found that the boat was just gliding away from the pier. The plank had been taken in, and the cable by which she had been made fast to the pier, had been cast off, and the hands were drawing it in. Marco might have jumped across to the pier, but he reflected that their trunks were on board, and it would not answer to lose them. Just then he saw his cousin Forester leaning against a sort of pillar which supported the upper deck. His countenance wore a very quiet and composed expression. Marco ran up to him and exclaimed,



“Cousin Forester, we’ve got into the wrong boat.”

“I know it,” said Forester, coolly.

“Well, what shall we do?” said Marco, in the greatest perturbation.

“Don’t you know what it is best to do?” asked Forester.

“No,” said Marco, “I’m sure I don’t.”

“Then I advise you not to be in such a hurry and flurry,” said Forester. “The time to be in a hurry, is when we know exactly what to do, and have but a short time to do it. When we don’t know what to do, we ought to calm and compose ourselves, and take time to think.”

“Why, if we were only ashore,” said Marco, “we would go back, and find the right boat to go to Albany.”

“But we are not on shore,” said Forester, “and we can’t get on shore; so that supposition does not help us any.”

“Why, the captain would put us back,” said Marco, “I’ve no doubt, if you would only ask him.”

“Perhaps he would,” replied Forester, “but I’m only a feeble old man, you know, travelling under your care. You must go and ask him, if you want him to put us ashore.” Here Forester laughed aloud, at the ludicrous predicament which Marco had got into. As for Marco, he tried to look grave, but he could not entirely suppress a smile which struggled to appear upon his countenance.

“I don’t think it is any laughing occasion, myself,” said Marco, after a pause. “Besides, I sup-

posed that if we got into any serious difficulty, you would help me out of it."

"So I would," said Forester, "but I don't conceive that you have got into any serious difficulty yet. We may as well go to Vermont by the way of New Haven and Hartford, as any other way. You see we can go up from Hartford to Springfield, and there we can take the rail-road to Boston. There will be one great advantage in taking this route, for we can visit the great national armory at Springfield."

"What is that?" asked Marco.

"Why, at Springfield," said Forester, "the government of the United States have a great establishment for manufacturing muskets for the national armies, and it is a very curious and interesting place to visit."

"What can we see there?" asked Marco.

"O, all the processes in manufacturing muskets," said Forester. "The first is the work of the great trip-hammer, which goes by water, and forges out the iron plates, which the muskets are made from. These plates are bent round over a long iron rod, and welded, and thus the barrels are made. Then these barrels are bored by various machinery, and the outside surfaces turned. Then the forging and grinding of the bayonets is very interesting."

"I shouldn't think there would be anything very interesting in grinding," said Marco.

"There is," said Forester. "Grinding an axe

on a hand grind-stone is n't a very wonderful process, to be sure,—but in these large establishments, where they grind on such a great scale, the enormous stones, and the speed with which they revolve, and the streams of sparks, which fly out, strike you with wonder."

"Yes," said Marco, "I should like to see them."

"Then there is a great deal that is curious in making of the locks," said Forester; "forging out all the small parts, and filing, and polishing them, and then the putting of them together. You will be very much interested, I've no doubt."

"Well," said Marco, "I don't care much about our getting in to the wrong boat." So he went away from Forester, intending to go up upon the upper deck again.

He came back, however, a moment, to tell Forester that there was a deaf and dumb boy on the deck above.

"Where is he going?" said Forester.

"To Hartford," said Marco.

"Very likely he is going to the asylum," said Forester.

"What asylum?" asked Marco.

"Why, there is an asylum," replied Forester, "in Hartford, where the deaf and dumb go from all parts of the country, to learn to read and write."

"Yes," said Marco, "he can write. He has a slate."

“Then I have no doubt,” said Forester, “that he is a pupil of the asylum at Hartford. You had better get him to tell you about that establishment, and ask him to teach you the manual alphabet.”

“What is the manual alphabet?” asked Marco.

So Forester explained to Marco that the manual alphabet was a mode of representing the letters of the alphabet by the fingers of the hand, and that those who understood that alphabet, could talk, by means of it, with the educated deaf and dumb.

Marco was very much interested in this idea, and he returned to the upper deck, and sat an hour with Erskine, learning the manual alphabet, and writing in dialogue with him, on his slate. They were once interrupted in their occupations, by a colored man, who went about the decks, ringing a great bell, and calling out to all who had not paid their fare, to call at the captain’s office and settle. Whereupon Marco left Erskine for a short time, while he went to the window of the captain’s office, on the lower deck, and after waiting there some minutes among the crowd, until his turn came, he took two tickets for Hartford, one for himself, and one for Forester.



CHAPTER II.

THE FLOOD.

THE two travellers arrived safely at New Haven, where, on leaving the steamboat, they entered a train of cars which were to take them to Hartford. Hartford is on the Connecticut river, and Springfield is on the same river, about twenty-three miles above. The travellers expected to have gone up the river that afternoon, by a small steamboat, which Forester told Marco was accustomed to ply between Hartford and Springfield,—but when they reached Hartford, they were told that there was no boat. Marco went to the bar of the United States Hotel, where they put up, to inquire the reason. They told him that there was a great freshet on the river, and the boat had not been able to get down. So Marco went with this intelligence to Forester, who was reading the Boston newspaper in the gentlemen's parlor.

“I don't see why a flood on the river, should keep the steamboat from coming down,” said Forester.

“That is the reason, I know,” said Marco, “for they told me so at the bar. Perhaps it is because the water runs too swiftly.”

“That might prevent the boat from going up,” said Forester, “but I don’t see how it could keep it from coming down. I should think it would come down all the faster.”

“Perhaps the flood brings down ice and logs, so that the boat can’t get along,” rejoined Marco.

“I don’t think that is a very probable explanation,” said Forester. “It is much more likely that there is some mistake in your information.”

Marco felt a little piqued at having his information thus called in question, and he went back to the bar to inquire how a freshet could keep the boat from coming down. They told him that there was a bridge across the river, some distance above, and that the boat could not get under it when the water was high. This seemed very satisfactory, and Marco went back with the explanation to Forester, who seemed satisfied with it too.

It was late in the afternoon when they arrived at Hartford, and although it was very pleasant when they left New York, yet the sky had become overcast during the day, and now it began to rain. Marco, however, was very eager to go out, after dinner, to see the flood, and Forester concluded to go with him. It was so late when they arrived, and the evening came on so early, that it was not till just before dark that they got ready to go out. They first went to the state-house, in order to ascend to the cupola, to take a view of the flood from that elevation. The state-house at Hart-

ford is in the midst of the city, and a broad street descends from it to the river. Forester and Marco went up by various flights of stairs, until, at last, they reached the summit, where they had a grand view of the city, and of the river, expanding into a vast sea, which spread over the valley, with groves, farm-houses, orchards, and even the streets of the city rising out of the water.

After looking upon this scene for some time, they descended again, and followed the street down towards the bank of the river. But long before they reached the bank, they found the streets filled with water. Barrels and boxes were floating about, piles of merchandise, which had been taken out of submerged cellars, were arranged along the sidewalks, where they were out of the reach of the water, and men were busily at work, getting other goods into places of safety. By this time, however, it became dark, and the wind and rain seemed to be increasing; so Forester and Marco returned to the hotel, anticipating much pleasure in taking a walk in the morning, when they could examine the effects of the flood to better advantage.

They were called the next morning at six o'clock, and were told that the boat had come and was going to start at seven for Springfield. So they dressed themselves with all speed, and hastened down to breakfast. They had hardly time to finish their breakfast, when the coach was at the door to take them to the boat. They got in, and after riding

through several streets, descending all the time towards the water, Marco, who had his head out of the window, looking forward, said,

“Cousin Forester, look here,—the street is all full of water. We can’t go but a very little farther.”

Marco expected that as soon as the carriage had gone as far as it could go on the firm pavement, it would stop at the brink of the water, and that some other plan would be adopted for conveying them to the steamboat. What that plan would be, he could not at first imagine; but in a moment there suddenly glided into view a little skiff, that came down the street that crossed the one in which they were riding, at right angles to it, at some distance before them. The skiff came into view from behind a block of brick buildings, which formed a corner of the street, and passing across the street which Marco was in, kept on, and soon disappeared. There was a man in it, rowing.

“He ought to come,” said Marco, “with his skiff, and take us along.”

By this time the horses had reached the brink of the water; but, to Marco’s surprise, they did not stop, but advanced slowly into it, drawing the coach after them. The water grew deeper and deeper, until, at length, the horses were up to their knees. At some distance before him, at the extremity of the street, Marco could see the end of the bridge which led across the river; but he saw no steamboat. However, it was some relief to

Marco to see the bridge, as that promised to be, at least, the termination of their ride; for he did not at all like navigating such deep water in a carriage. The water, however, did not grow any deeper, and presently, just before they reached the bridge, it began to grow shallower, and soon the carriage stopped at a place, where there was a small piece of dry land, big enough for them to stand upon. Here the little steamboat came in sight too, which was to take them up the river. By scrambling along through a store, and over planks, and along the edges of piers, they succeeded, at length, in getting on board.

There were some ladies in the coach, and they, with the gentlemen who had charge of them, went down into the ladies' cabin. The steamboat was very small. It had a great paddle-wheel at the stern, and two small ones at the sides, one at each side. "These last," Forester said, "he supposed must be to aid in steering." The boat reminded Marco of the canal-boats, which he had seen on Erie canal. It was similar in construction to those boats, though larger. It had, like a canal-boat, a small fore-castle, which was below the level of the main decks, and very near the water. From this fore-castle, Forester and Marco went down into a little cabin, which was, of course, near the bows. The ladies' cabin was towards the stern. In the cabin, they were sheltered from the wind and rain, but they did not remain there long, as they wanted to look about, and observe the effects of

the flood, and the strange aspect which was given to the whole surrounding scenery, by such a deluge of waters, in which everything seemed submerged.

“All this,” said Forester, “comes from the melting of the snows, away up among the mountains. I should think that Hartford might be about at the place where the height of the waters would be a maximum.”

“I don’t understand what you mean by that,” said Marco.

“Why, you will see, by reflection,” said Forester, “that up near the sources of a river, there never can be a very high flood, for the streams are all small, and they descend rapidly down the sides of the mountains, and thus the water runs off fast, making a torrent, rather than a flood. These small streams join together, and other branches come in from each side, and thus the river is formed, and when it gets upon lower land, where it is more level, so that the water cannot run off so quick, it rises higher, and spreads over the meadows on each side. The great body of water moves on slowly now, and is increased by every branch which comes in from each side, until the height of the water becomes a maximum,—that is the greatest.”

“Why does it not keep on increasing all the way to the sea?” said Marco.

“Because,” replied Forester, “when it gets within the influence of the sea, the water flows out freely

into the sea, and spreads off over the ocean. A flood in a river is sometimes twenty or thirty feet above the common level of the water; now if it were to be so near the sea, there would be a steep descent from the river to the sea of twenty or thirty feet, which you see could not be. For the water, when it gets near the sea, if it was at all elevated above it, would press down from the river by its great weight, and spread out into the sea so rapidly, as to keep the water down for many miles up the river. Thus, if a bird were to begin in the mountains, when a great fall of rain took place, and follow the flood down, she would find it increasing, and becoming higher and higher as it advanced, until it reached the level plains, and it would go on, inundating them more and more, and spreading out over intervalles and meadows, until, at last, like a great wave which had begun to spend itself, it would not rise quite so high, though it would still keep advancing; and thus, if she was a reasonable bird, she would know that the water was coming under the influence of the sea. After this, the freshet would rise less and less high as it advanced, until it reached the mouth of the river, where it would scarcely produce any perceptible effect at all."

"Then there cannot be any freshet at the mouth of the river," said Marco.

"No," replied Forester, "there can be none caused by floods from above. Sometimes, however, a storm at sea, when the wind blows in

towards the shore, raises the water several feet, and makes a sort of inundation, in that way, though it seldom rises more than four or five feet above high tide."

By this time they began to push off the boat from the pier, and the great paddle-wheel at the stern of the boat began to revolve, and they swept out into the stream. They were just above the great wooden bridge, which stretches across the Connecticut, at Hartford. Marco saw that the water was up to within a foot or two of the floor of the bridge, and some of the men said that it was very fortunate that there was no ice running.

"Why?" asked Marco.

"Because," replied the man, "it would soon make a jam above the bridge, and carry it away."

Marco observed that the water was turbid, and its surface was strongly agitated by whirlpools and eddies. Marco went forward, and took his place upon the forecastle. The wind was northeast, and thus was almost against them, and it blew the cold rain into Marco's face. He attempted to hoist his umbrella, but a sudden gust caught it out of his hands, and swept it along the upper deck. Marco scrambled up the steps, and ran after it. It lodged, very fortunately, under the bows of a little skiff which had been placed upon the deck in order to be taken up the river. If it had gone over into the water, it would have been irrecoverably lost, as

it would not have been worth while to detain the boat for it.

When Marco got his umbrella, he went back to his station again, but when he opened it this time, he was careful to present it to the wind in such a manner that the wind could not get under it again. He then peeped out under it, to survey the wide waste of waters, which extended as far as he could see on either hand. The ordinary course of the river itself was entirely undistinguishable, and, instead of it, there was a broad sea of turbid water, agitated by the wind and by whirling eddies, and spreading over fields, farms, villages, orchards,—extending, at the extremity of the view, far in, under the trees of the forests.

It was a melancholy sight to see the farm-houses, some with the water up above the floor, or even to the windows; and others standing on a little spot of ground, which the water seemed just ready to cover, with the family standing at the door, gazing at the unexpected spectacle of a steamboat going across their mowing-fields; for the water being deep enough everywhere, the boat was not obliged to confine itself to the ordinary channel of the river, but made a straight course, over fields, fences, yards and gardens. Once or twice, Marco perceived that they were going through an orchard. The tops of the apple-trees were about half out of the water. Marco thought that if it were only the right season, they could get some apples; but, as it was, the trees were

leafless and bare. At some of the farm-houses, men were busy, securing their goods and furniture; at others, they were gliding about in skiffs, and in one case, Marco saw a man and his boy going out to the barn, to take care of the cattle, on a raft made of the barn doors.

At half way between Hartford and Springfield there is a fall, or rather a rapid, through which boats cannot go either up or down. They cannot go up, because, even when the water is deep enough, they cannot stem the current; and they cannot come down, because the current would sweep them along too swiftly, and dash them against rocks on the shore. So they had made a canal around this fall, in order to take the boats up, or let them gently down, by means of locks, in the manner explained in "Marco Paul on the Erie Canal." This canal was, however, now submerged, and the steamboat had to stop below it, at a little village called the Point, from whence the passengers were to be taken the rest of the way by stage. When they arrived at this village, they sailed along in front of the principal street, and then turned into another at right angles to it, in which the tavern was situated. The helmsman brought the boat up to the piazza of the hotel, as if it were a wharf. The passengers stepped out upon it. It was covered with people of the village, who had collected there.

The tavern was entirely surrounded with water and from the piazza, there was a view of a large part

of the village, with the streets, yards and gardens entirely submerged. Barrels, boxes, and planks were floating about. All stood upon the steps of



the platform, watching the scene. First, a wheelbarrow came slowly drifting into the tavern yard; then a boy on a raft made of two planks. Then a little boat glided by, full of children, going home from school. There was a bridge, made of a line of planks, leading across from the platform to the land behind the tavern. The ends of the planks were supported by horseblocks, for piers. Marco ran back and forth across this bridge several times, until, at length, the stages were ready. They were backed down through the water, to the steps of the piazza, and the baggage was put on. The stages were then driven out to the dry land,—the passengers went, one by one, over the long plank bridge, took their seats, and thus they all proceeded to Springfield.



CHAPTER III.

THE WATER SHOPS.

ON the morning after Forester and Marco arrived at Springfield, they sallied forth from their hotel, to see the works of the armory. The village of Springfield is one of the most beautiful villages of New England. The business part of it lays along the bank of the Connecticut, on a sort of plain; and from this plain, streets ascend to more elevated land behind it, which is covered, in every direction, with handsome villas, overlooking the village and the river, and the broad and beautiful valley of the Connecticut.

The principal buildings of the armory are situated upon another plain, which extends back from this elevated land, at the distance of perhaps half a mile from the river. The buildings are very large and handsome, and are arranged around the sides of a spacious square, which is ornamented with walks and rows of trees. Marco thought that the whole looked like the buildings of a college. There was one edifice in the centre of the principal front of the square, which had a cupola upon it, as if it were a chapel. Forester told Marco that it was the office and counting-house.

The other buildings were shops and store-houses, —though Marco thought that they were very splendid buildings to be used for such purposes. On one side was a long row of houses, which were used for the residences of officers and others connected with the armory. From this central square, streets diverged in every direction over the plain, which were bordered with small, but very neat and pleasant houses for the workmen. These houses were ornamented with trees and shrubbery, and surrounded with pleasant yards and gardens. The whole scene presented, on every side, a very pleasant prospect to the view.

After looking at it for some time, Marco proposed going into some of the buildings, but Forester said that he thought it would be better to go first to the water shops.

“What are the water shops?” asked Marco.

“Why, you must understand,” said Forester, “that in making a musket, there is a great deal of light work to be done, and also a great deal of heavy work, and this last can be done best by the help of machinery. Now there is a little stream, south of Springfield, which runs into the Connecticut, just below the town. So they have built three dams across this stream, and built shops near the dams, with water-wheels under them, to be carried by the water. Here they do all the rough and heavy work which is required.”

“What is the rough and heavy work?” asked Marco.

“Forging the barrels is one thing,” said Forester; “that is very heavy work.”

“I don’t see how they can forge the barrels,” said Marco. “They could n’t make them round, nor hollow; if they were to strike upon them, when they are hot, it would flatten them in. So I think they must make them in some other way.”

“No,” said Forester; “they forge them with heavy trip-hammers, as you will see. They have peculiar contrivances to keep them hollow, and to make them round. Then the grinding and polishing is heavy work.”

“The grinding,” said Marco, “but not the polishing. The polishing must be very nice work.”

“It may be nice work, but still it requires heavy machinery to do it,” rejoined Forester. “For polishing is done by means of wheels, which are made to revolve with prodigious velocity, and then the things to be polished are held against the circumference of them. Now it is not heavy work to hold the article against the wheel, but to make the wheel revolve so very rapidly, requires heavy power in the machinery.”

“How fast do the wheels revolve?” asked Marco.

“I don’t know,” said Forester; “we can ask the workmen, when we come to the polishing rooms. At any rate, it is a great many times in a second, and it requires a water power, and

machinery to turn them so fast. Then there is the boring, and the turning, and the milling."

"What is the milling?" asked Marco.

"Why, in some cases," said Forester, "instead of finishing the work with files, they cut it down to its proper form by wheels of steel, with teeth like those of a file, cut upon them. These wheels are made to revolve very swiftly, and the iron or brass is made to bear against them, and also to move along at the same time, and so it is cut down to the exact shape required."

"Why don't they hammer it into the right shape in the first place?" asked Marco.

"They can't hammer it into precisely the right shape," said Forester; "and, besides, the surface which is left by the hammer is not perfectly sound. There are small flaws and scales in it, so that the metal must be cut away a little, to come down to where it is sound. So they forge it to pretty nearly the proper shape, leaving it a little too large, and then mill it down to the precise form, or else file it, if the shape is so irregular that it can't be milled."

While Forester and Marco had been engaged in this conversation, they had been slowly walking along in the direction which Forester said led to the water shops. The road which they took was straight, and it traversed the plain, which has already been spoken of, in a southerly direction. It was bordered, for a part of the way, with the neat and pleasant-looking houses of the armory

workmen, and beyond these there were extensive fields, traversed by various roads, the view being terminated in the distance by occasional glimpses of the great valley of the Connecticut, with the mountains beyond. There was one rounding summit off at the north, which Forester told Marco was the famous Mt. Holyoke, near Northampton.

“What is it famed for?” asked Marco.

“For the prospect which you can have from the summit,” said Forester. “The mountain is close to the Connecticut river, and rises abruptly from the valley, so that, from the summit, you look down upon one of the most rich, and verdant, and populous regions of the land, covered with farms, fields, villages, and verdant meadows, and with the Connecticut winding beautifully through the whole. It is very different from most mountains in this respect.”

“Why, how is it with other mountains?” asked Marco.

“They are surrounded, generally, by lower mountains and hills, or, at least, they rise out of a rough or mountainous country; so that the transition is gradual from the level and fertile land to the high elevations. But Mt. Holyoke rises abruptly from the midst of one of the richest scenes in the land; so that you can ride in your carriage so near to it that the remaining ascent is only going up stairs.”

“Have they really got stairs?” said Marco.

“Yes,” replied Forester; “a kind of rude stairs, made of stones or of logs, placed across the way.”

“I should like very much to go to Mt. Holyoke,” said Marco. “I’ve a great mind to go that way.”

“It is not the right season of the year,” said Forester, “to enjoy the excursion. We want the month of June.”

By this time they had arrived at the end of the plain, and they began to descend, by a winding road, into the valley where the water shops were situated. It was a beautiful glen, shaded by trees, with the mill stream flowing through the centre of it. There was a road, leading up and down the valley, on each side of the stream, and, at the point where they came to it, there was a bridge across it, connecting one of these roads with the other. Above the bridge was a dam of handsome mason work, with various flumes for conveying the water. There were also some large and handsome shops, on each side of the stream, with torrents of water pouring out from beneath them, indicating that they contained machinery which was carried by water.

Forester told Marco, that there were three water shops on the stream, about half a mile apart, and that this was the middle one.

“I should n’t think that they would want to have them so far apart,” said Marco.

“It is probably on account of the stream,” said Forester. “They have to put the shops where

they can get a good fall of water, and it happens, I suppose, that the falls on this stream are at that distance from each other. They build a dam on each fall, and construct works to employ the whole power that they obtain there,—that is, the whole *minimum* power.”

“What is the minimum power?” asked Marco.

“All the power which they can have constantly in use, all the year round,” replied Forester. “A stream of water is not constant, you know. After rains, it is much greater than after a drought. Now suppose there was a brook with water enough, in mid-summer, to turn a large grindstone, and no more; of course, that brook, could turn that grindstone all the year, unless there was a basin above the dam, which would retain the water after a rain, and deliver it out afterwards, in drought, so as to give a greater power than the stream alone would give. Perhaps, in this way, with the help of a reservoir of water, the stream would carry two such grindstones all the year round. This would, then, be its minimum power. But for one half the year, that is, all through the spring and fall months, there would probably be twice as much water; so that, during that time, it would carry four grindstones. Thus, when people speak of the minimum power of a stream being all employed, they mean all the power which it can exert, steadily and constantly, all the year round. Then, above that, there is a considerable power which may be used at certain sea-

sons, if it is worth while to construct machinery to employ it."

"And is it worth while, generally?" said Marco.

"Yes," said Forester, "though it depends somewhat on the nature of the business. For instance, in saw-mills, they can run one saw during the summer months, using the minimum power; and then, when the stream swells, in the spring and fall, they can set more saws a-going, thus employing the surplus power. Still it is a disadvantage to have a great surplus power. It is much better to have the stream steady all the year round."

"Yes," said Marco, "that is plain enough."

"True," replied Forester, "but all the reasons for it are not very plain."

"Why, they can keep their works a-going all the time," said Marco.

"Yes; but why would n't it do as well," said Forester, "to keep twice as many works going half the time?"

"Why——, I don't know," said Marco, hesitatingly.

"Because, it would take twice as great an investment of money to construct the works. Two saws, running six months each, would saw as many logs as one running a year; but then it would cost twice as much to put them up, with all the necessary machinery; and then it would take twice as many men to work them, and these men would have to be dismissed for six months in

the year, and go away, and seek other employments. This would be inconvenient, and be attended with increased expense."

"There is a very great difference in different streams," said Forester, "in respect to their steadiness. Some streams are pretty nearly the same all the year. They are not much increased by rains, or diminished by droughts. Others are very small in mid-summer, and then, in the spring or after long rains, they are torrents, capable of carrying ten, or even a hundred times as much machinery as their minimum power would carry. Though, in such streams, sometimes the water-wheels, adapted to their ordinary flow, are all submerged and overwhelmed, and so stopped entirely; or the dams are undermined, or torn up, and the mills themselves carried away."

"I don't see why there should be any such difference in the streams," said Marco; "I should think they would all have freshets after the rains."

"There is a vast difference," said Forester. "It depends upon the source of the water which supplies the stream. There are three kinds of streams, in respect to the source of their waters; or, rather, there are three different sources from which the water of brooks and streams is supplied,—ponds, springs, and rain. A brook may flow out of a pond, or it may arise from springs, or it may proceed from rains, which fall upon a valley, and run down through the lowest part of

it. Now a stream that comes from a pond does not rise and fall very much, because the pond keeps, at almost all times, near the same level. The water which falls upon it, in rain, spreads over so great a surface, that it does not raise it more than a few inches generally, and, of course, the stream flowing from it rises only in proportion. It is so with streams which come from springs, or great swamps, which are full of springs. But where a stream comes from a great valley, extending many miles, so as to catch and drain off all the water which falls on the valley, you see it must necessarily become a furious torrent in the spring, when the snow is melting over the whole valley, or after a powerful rain."

"Yes," said Marco. "I never thought of that difference in the brooks before."

While this conversation had been going forward, Marco and Forester had come down into the valley, and had been walking up and down under rows of trees, which had been planted on the banks of the stream, admiring the beauty of the prospect. They now turned their steps towards one of the great shops, where they heard a loud sound, as of heavy machinery in motion, and Forester opening the door, they both went in.

CHAPTER IV.

FORGING.

THE room which Forester and Marco had entered was a very large apartment on the ground floor, and not well lighted, except by the blazing fire of the forges. There were rows of forges extending through the whole length of it, which were glowing with the intense heat of anthracite fires, urged by bellows which were carried by water. Connected with each forge was a great trip-hammer. A trip-hammer is an enormous hammer, worked by water. The handle is a beam of wood, perhaps ten feet long. This handle moves on an axle near the end of it. The end of the handle projects a short distance beyond the axle on which it turns, and is armed at the extremity with iron, and beyond it is a wheel with projecting cogs or pins of iron, which strike against the end of the handle, as the wheel turns round, and drive it down, and this makes the head of the hammer rise up. Then, when the cog in the wheel, which had struck against the end of the handle, slips by, it lets the end of the handle up, and the head of the hammer of course falls down

upon the anvil, or rather upon the work placed upon the anvil to be forged.



There is one thing more, which it is very important to observe, in respect to the operation of the trip-hammer, and that is, that when the wheel containing the cogs, revolves fast, it throws the hammer up so violently as to spring the beam of wood which forms the handle, and the head is then brought back again to the anvil, by the elastic return of the handle to its position, with great force. Persons that do not understand the operation of the trip-hammer, are often surprised to see the head of it not so large, in proportion to the other parts, as they had expected to see it. They think that if the head were heavier it would descend with more force, and do more work. This would be the case, no doubt, if it were by the simple weight of the head that the work was done.

But it is not. It is by the elastic force of the handle, which brings down the head to the anvil with great power, after being violently thrown up by the cog behind, just as the effect of the common hand hammer, in a blacksmith's shop, is due not so much to the weight of the iron in the head of the hammer, as to the force of the arm which wields it.

Each of the trip-hammers, connected with the forges, were so connected with machinery, that they could be made to go very swiftly, or be entirely stopped. While the iron to be forged was in the furnace, heating, the trip-hammer remained at rest, but when they wanted to use it, they could set it in motion, fast or slow, according to the work which they wanted to do. Now when Marco and Forester came into the building, the workmen, at some of the forges, were heating the irons; at others, they were hammering quickly, and at others slowly; and every moment Marco observed a long, red-hot gun-barrel, drawn out of a furnace, and pushed under a trip-hammer, and then, by some movement of the workmen, the hammer would suddenly begin its blows, with the greatest rapidity and force, throwing the sparks about in every direction, and filling the whole place with a deafening din. Then, after a few minutes, by some other movement of the workmen, the hammer would be made to cease its rapid movements, and to strike more slowly. Presently, it would cease altogether, and the iron

would then be drawn out from under it, and put back into the fire to be heated again. Every time one of the trip-hammers was thus set in motion, it produced a rapid succession of loud reports, like a discharge of musketry; and these volleys of sound were continually breaking out over the great apartment, as the men happened to get the barrels heated at the several forges.

After standing a few minutes, and looking at the general scene, Forester drew up to one of the forges, to examine the process in detail. They found that the barrels were made of flat bars of iron, bent over around a rod, which kept them hollow. When one of these bars had been bent up, so that the two edges would lap over each other, it was put into the furnace, and heated very hot, and when all ready, it was drawn suddenly out, and slipped under the trip-hammer. The anvil had a groove in it of a cylindrical form, and the hammer had another one corresponding to it, so that if a finished barrel were placed between them, it would just fit into the space left by the two grooves when the head of the hammer and the anvil came together.

There was such a continual succession of loud sounds made by the trip-hammers all around them, that Forester had to put his mouth close to Marco's ear, and talk very loud, in order to be heard. Speaking in this manner, he said,

“ Now you see, Marco, how they avoid the two difficulties which you apprehended. They keep

the barrel hollow, by having a rod inside, and they keep the outside round, by having a groove in the anvil and in the hammer.”

“Yes,” said Marco, “I see. I did not think of those plans.”

Just then, one of the men at the forge nearest them, was drawing out a barrel from the furnace, which was of a very intense heat. It was almost white. Forester called Marco to stand back a little, lest the sparks should fly upon their clothes.

The man run the barrel back again, to heat it hotter still. It was, however, only the half which was in the furnace, which was hot. The other end the man kept cooling, by wetting it constantly with cold water. He wanted the end to take hold of. The end which was hot was the biggest end of the barrel. In a moment more, he drew it out again, and then struck it down upon an iron plate upon the floor, with great force, two or three times, to square the end. He then run it under the trip-hammer, slipping the rod into it at the same time. The rod was placed by the trip-hammer, with its end in such a position, that when he pushed the barrel under the hammer, the rod entered into the hollow of the barrel, and kept the hammer from closing up the bore. There was a sort of pole hanging down as a handle from one part of the frame of the trip-hammer, and another man was standing near it. When the hot bar was in its place under the hammer, this man pulled down the pole, and immediately the trip-hammer began

its blows upon the iron, while the workman who held it, turned it round and round continually, that it might be struck successively on all sides. Thus he worked that into a very round and smooth form, and then the pole was pushed up, and the trip-hammer stopped. As the other end of the barrel had been served in the same manner before, it was now finished, and he put it upon a rack, with a great many others, which were done before.

By this time, another barrel was ready at the next forge, which was in a different stage of its progress. One half of it had been nearly finished, but at the other end the edges of the barrel had not been welded together. They had been brought round over the rod, but had not been joined. Marco looked on while the workman heated the unfinished end and then placed it under the hammer. The heavy blows soon brought the edges together, and joined them around the rod, so as to give it the form of a gun-barrel throughout. Marco saw that when the workman wanted the hammer to strike slowly, he could regulate its motion, in some way, by putting his foot upon a projecting bar of wood, close to the floor, upon one side of the anvil; or, if he wished, he could stop it entirely.

After this, Forester and Marco sauntered slowly through the room, looking at the various forges. There were great heaps of coal near them, and men were wheeling in fresh supplies over the

stone floor. There were troughs of water at each forge, with a little stream, from the mouth of a lead pipe, running into each, which kept them constantly full. The fires in the forges were very hot, being kept up by a steady blast of wind from some unseen bellows. After spending as much time as they wished in this building, Forester and Marco came out, and went across the stream by a bridge. They stopped upon the bridge, and looked over into the stream. The water was pouring along, in a tumultuous manner, between the walls of masonry which formed the buildings or the banks on each side.

“Now here is a stream,” said Forester, “which I should think was pretty uniform and steady.”

“Why,” said Marco, “how can you tell?”

“I can tell by the looks of the water.”

“It seems to me very strange,” said Marco, “that you can tell by the looks of the water in a brook, whether it comes from a pond, or springs, or a great valley.”

“I could n't tell,” rejoined Forester, “except at such a time as this, that is, just after a powerful rain and thaw, which must produce a freshet in every stream capable of a freshet. Now, look for yourself into this water,” continued Forester, “and see if you observe any difference between this and the water of the Connecticut.”

“Only that the water of the Connecticut is muddy now,” said Marco.

“And how is this?” said Forester.

“This is clear, only it is of a dark color.”

“Very well,—and what do you suppose is the reason why the Connecticut is so turbid now?” asked Forester.

“Because of the freshet,” said Marco.

“But why should the freshet make it turbid?”

“Why, I don’t know exactly,” said Marco.

“The reason is,” said Forester, “that the freshet is produced by rains and melting snows from a vast surface of ground, and from such surface water washes all the loose soil and light particles which come in its way, into the river. So that the water of a flood, produced by water falling over an extensive valley, is always turbid. When, therefore, I see such a mass of turbid water as is now flowing through the Connecticut, I judge it is water which has come from rain and snow from an extensive valley. But when I see a stream bring down only clear water like this, after such rains and thaws as we have had, I conclude that it does not come from the draining of an extensive surface of land, but from a pond, or else from springs.”

“And can you tell, from the looks of the water, whether it comes from a pond or from springs?” asked Marco.

“Why, the water is pretty dark,” said Forester.

“And what does that indicate?” asked Marco.

“It indicates,” replied Forester, “that the stream comes from springs, and swamps which are fed by springs. The way in which swamps are formed,

is this. When springs arise in flat land, or in any places where the water cannot run off as fast as it issues from the ground, it spreads over the surface, and keeps it wet. Then all the plants which grow on dry land are killed, and none but aquatic plants will grow. And these aquatic plants, when they die, do not decay. The water preserves them, and other plants grow above them. The leaves too, and branches, and trunks of trees, which fall in, are covered with moss, and aquatic plants, and water, and are thus preserved; and in this manner a great depth of vegetable substances is formed in process of time, the water issuing continually from the ground beneath, and the surplus flowing off in some little brook or stream."

"Yes," replied Marco, "I see it is, and I have often observed it so in other brooks."

"But the water which comes from ponds has generally but little color."

"What makes it so dark when it comes from swamps?" asked Marco.

"I do not know," replied Forester, "unless it be that the plants and vegetable remains, half decayed, which lie soaking in the swamp, color it."

Just at this moment, a man appeared, coming out of a shop on one side of the stream, with some curious-looking piece of machinery in his hand, and he advanced towards the bridge, as if he were going to cross it.

“Ask him,” said Marco, “if this stream rises much in freshets.”

Forester said he would, and accordingly, when the man had come opposite to them, Forester accosted him, by saying,

“The freshet does not appear to affect your works much on this stream.”

“No, sir,” replied the workman, “it never does.”

“What is the reason?” asked Forester.

“Why, the stream is fed,” replied the man, “almost entirely by large springs, a short distance from here, and the rain does not raise it much.”

“So, then, you are never troubled much with back water,” said Forester.

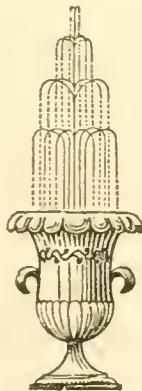
“No, sir,” replied the man, “not at all.” So saying, he passed on.

“What do you mean by back water?” asked Marco.

“When the water below the dam,” replied Forester, “does not run off fast enough, but flows back against the water-wheel, so as to prevent its being turned round by the current above, it is called back water by millmen. Sometimes, when there is another dam a short distance below, it obstructs the water, so that, in times of freshet, it cannot escape fast enough, and so the upper mill is troubled with back-water. And even when there is not any other dam, if the natural bed of the stream offers obstruction, or if the descent is not great enough to carry off the water easily,

then, when any unusual quantity comes, it makes difficulty. But come, let us go into the next shop."

So Marco and Forester went over into another shop. Here the workmen were forging out the plates of iron, and flattening down the edges, and then bending the edges over towards one another, ready to be lapped and welded. There were several trip-hammers here, and Marco had a better opportunity to observe the construction of them than in the great forge room. He was surprised to see how perfectly they could regulate the blows, strike slowly and carefully, or quick and strong, at their pleasure. The workmen were exceedingly accommodating in answering all the questions they asked, and in explaining everything which was going on. They seemed, in fact, to take a pleasure in doing it.





CHAPTER V.

IRON.

ON the walk from the middle water shop to the upper one, Marco asked Forester why they did not make gun-barrels of brass, instead of iron; he said that they would be handsomer.

“I don’t know,” replied Forester. “They make cannon for field-pieces, of brass, but that is not on account of their beauty, I believe; perhaps because they can be made lighter, and yet of the same strength, when of that material; but iron is always used for musket and pistol barrels, I believe. I rather think this may be it: iron cannon are always made of cast iron. Now brass may be stronger than cast iron, and yet wrought iron may be stronger than brass. Still this may not be all the reason. The various metals have so many various properties, that it would require a great deal of study to be acquainted with them all.”

“I read in a book once,” said Marco, “that iron is really more valuable than gold.”

“Yes,” said Forester, “that is true.”

“And that all which made gold valuable,” continued Marco, “was its scarcity.”

“No,” said Forester, “that is not exactly true. All that makes gold *more* valuable than iron, is its scarcity.”

“Yes,” said Marco, “perhaps that was it.”

“There is a great difference between these two statements,” said Forester. “And then, besides, there is an ambiguity in the meaning of the word valuable.”

“Valuable!” repeated Marco; “I did n’t know that there was more than one meaning to that.”

“What does it mean?” asked Forester.

“It means worth something,” replied Marco.

“Is water valuable?” asked Forester.

“Why, I don’t know,” said Marco; “we could n’t do without it, very well.”

“No,” rejoined Forester, “but still people will not pay anything for it, generally, for it is so plentiful that they can get it without paying. Thus it has a great value for its intrinsic qualities, but no market, or money value. Now if gold was as plenty as stones in the street, it would be very valuable in the former sense, for it has some qualities which no other metals have, and which are very important.”

“What are they?” asked Marco.

“Perhaps the most important,” replied Forester, “is, that it will not rust, or tarnish, by being exposed to air or water, and it will not be corroded by any common acids. If a drop of vinegar falls upon a knife-blade, it makes a black spot; and if you cut an apple with a common knife, it blackens

it. The acid of the vinegar, or of the apple juice, corrodes the iron."

"I thought that knife-blades were made of steel," said Marco.

"Yes," replied Forester, "but steel is a preparation of iron. So if iron is exposed to the air, and especially to water, it rusts, and is soon spoiled; but gold might remain half a century buried in the ground, without changing. Therefore, if gold were as plentiful as iron, it would be used for a great many things which iron is used for now, because iron is so common and cheap."

"What are some of the things it would be used for?" asked Marco.

"Why, for everything," replied Forester, "which did not require any great hardness, such as spoons, fruit knives, handles of doors, knobs, keys, and all kinds of vessels for use in a family, as plates, cups, &c.; also for all kinds of cooking utensils, as kettles, skillets, &c. I presume, too, it would be used for sheathing of ships, and for covering roofs of houses; and, in fact, for almost all purposes, where particular hardness is not required. Still, on the whole, iron is more useful to men than gold would be, for it has several qualities, of a very curious nature, which admirably fit it for our use. It has, in fact, two sets of useful qualities, which are very distinct from each other. One set relates to the facility of manufacturing it, and the other set to its usefulness when manufactured."

“I believe I know what one of them is,” said Marco. “You can hammer it when it is hot.”

“It undergoes three changes by heat,” said Forester, “which are all of great service in manufacturing it. First, it becomes more malleable and flexible. This is when it is red-hot. If it was as malleable and flexible when cold, as it is when it is red-hot, it would be unfit for most of its present uses. It would bend down, at once, under any load laid upon it, like lead. But, by becoming more malleable and flexible when hot, it can be formed into its proper shape, and then, on becoming cold, it resumes all its hardness and toughness again. It seems as if these qualities were given to it expressly for the advantage of man, as we know of no reason why heat should make it flexible and soft, rather than brittle, as it does brass and lead.”

“Does heat make brass and lead brittle?” asked Marco.

“Yes,” replied Forester; “if you drop a piece of hot brass upon the hearth, it will break to pieces. And did n’t you ever observe, when you are casting little anchors of lead, that if you attempt to take the anchor out before the lead is cool, it will break to pieces?”

“No,” said Marco, “I never cast any anchors of lead.”

“That is the way it does work,” said Forester; “but iron becomes very malleable and pliable as it grows hot, until, at last, when it is at a white

heat, a remarkable effect takes place, which is of great importance. That is, the surface softens. It does not melt, that is, become liquid, as lead does; but it softens in a peculiar way, so that, if you put two surfaces together, while they are in this state, and hammer them together, they join perfectly, and make one homogeneous mass."

"What does homogeneous mean?" asked Marco.

"All alike," replied Forester, "through the whole substance. The place where the junction is formed is just like all the rest of it. This is welding. I believe there is no other metal but iron, that softens in this manner upon the surface, at a great heat, so that two pieces can be joined together. This, you see, is of immense importance in manufacturing iron, for it is very often necessary to join parts together. They could not make the gun-barrels in the manner they do, if it were not for this welding property of the iron. As it is, they can take a flat bar, wide enough to make a gun-barrel when it is rolled up, and then, by rolling it up so as to have one edge lap well over the other, they can weld it and make it one solid mass. If you look at the barrel when it is ground and polished, you cannot find the least indication of any joint where one edge lapped over the other."

"And nothing else but iron can be welded, then," said Marco.

"Iron and steel," said Forester. "Steel can be welded to steel, or to iron. That is the way they

make almost all cutting tools. The cutting part is made of steel, but the rest of the instrument is generally made of iron—the two parts being made separately, and welded together. Where steel is welded to iron, you can generally see a joint, for the two metals are of a little different color. In a common table knife, you can almost always see this mark near the handle, where the steel blade was joined to the iron part, which goes into the handle.”

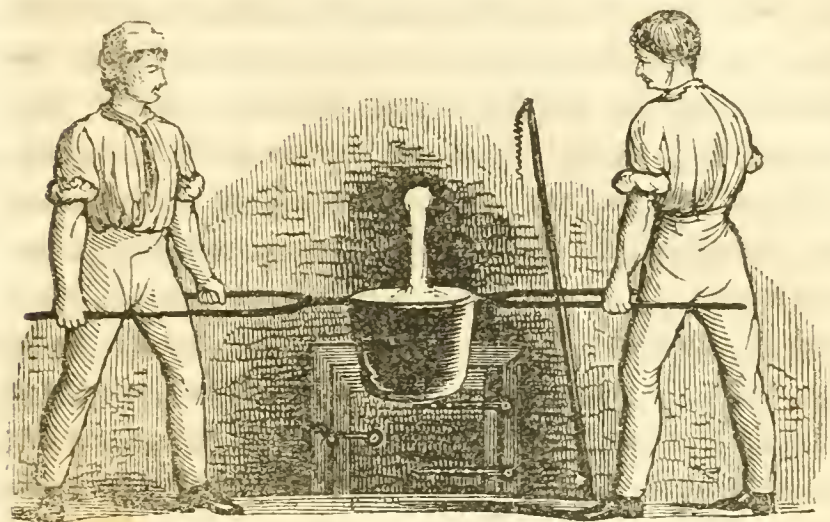
“I mean to look, the next time I see one,” said Marco.

“So in axes, chisels, plane irons, and all such tools,” continued Forester, “we can generally see, by careful examination, where the steel cutting part was welded to the iron shank. Then the fusibility of iron is another property of great importance in the manufacture of it. In a certain state, iron can be melted. They melt it in great furnaces, and draw it off through an opening in the bottom, which is kept stopped up till the iron is melted. When it is ready, they punch the hole open, and the melted iron comes out like a stream of liquid fire.”

“Where does it run to?” asked Marco.

“Oh, they hold a great ladle under it to catch it. The ladle is supported between two long bars for handles, and is carried by two men. When the ladle is full, they carry away the liquid iron, and pour it into the mould, made ready for it beforehand. When one ladle full is carried

away, two men are all ready with another, to put directly under, when the first is taken away, to



catch the stream of iron, which keeps running all the time.”

“Where did you see them cast iron so?” said Marco.

“Oh, I’ve often been in foundries,” said Forster, “where I have seen the process.”

“Why don’t they cast gun-barrels?” said Marco.

“They would not be strong enough. Cast iron is of a different nature from wrought iron,—is more brittle; and, besides, it is apt to have flaws. So that cast iron will not answer, where great strength and toughness is required, unless it is in cases where weight is no objection, as, for instance, where the article is not to be much moved. Thus, the cannons of forts, which are always stationary,

are of cast iron, but, in order to be strong, they have to be made enormously thick and heavy. But muskets, which the soldier has to carry upon his shoulder, must be made as light as possible. So they use the best wrought iron, and thus the barrels can be made much thinner than if they were of cast iron. You see that a soldier, besides his gun, has to carry his knapsack of clothes, and his powder and ball, and sometimes several days' provision; so that often, when on a march, he is loaded down with almost as great a burden as he can carry. With this, he has to travel through mud and snow, and sometimes through woods and swamps, and thus it becomes necessary to make the musket, and all his equipments, in fact, as light as possible."

"What makes them have it bigger at one end than it is the other?" said Marco.

"So as to have the iron thicker at one end. The bigness at that end is occasioned by the greater thickness of the iron there. The bore is of the same diameter throughout. You see that the chief force of the explosion of the gunpowder, is at the breech, where the charge lies. As the ball advances through the barrel, the gases expand, and their force diminishes, so that so great strength is not required at the muzzle. Cannon are always cast in the same manner, so as to have the greatest strength and thickness at the part which has to resist the greatest force of the explosion. There are, in fact, two reasons, why the force of the gun-

powder diminishes as the ball moves on towards the muzzle. The first is that the gases expand, and the second is that they cool."

"What gases?" asked Marco.

"The gases," replied Forester, "which are produced by the combustion of the gunpowder. When gunpowder burns, the solid parts, which it is composed of, suddenly combine, and change into gases. Now as the solid gunpowder occupied much less room than the gases which are formed from it, these gases expand with great force, to get their proper place, and that is what gives the explosive force."

"Is that the philosophy of it?" said Marco.

"Yes," said Forester, "in part; but that does not account for the whole explosive force of gunpowder. For if gunpowder is exploded in a confined space, so that they can collect all the gases which result"——

"I should think it would blow the confined place all to pieces," interrupted Marco.

"Oh, the chemists have a mode of arranging apparatus, to prevent that, and to keep the gases from escaping."

"How do they do it?" asked Marco.

"They drop the gunpowder, by degrees, that is, a few grains at a time, upon hot iron,—perhaps the end of a gun-barrel, and then have the other end of the barrel bent, so as to pass under water. Then, as the powder is inflamed and explodes, the gases pass out through the muzzle of the gun-barrel and come up in bubbles through the water."

“Yes,” said Marco, “but they would get away into the air and be lost.”

“Not at all,” said Forester, “for it would be very easy to have a vessel upside down over the place, to catch all the bubbles, or rather the gases that are in them. The chemists have very ingenious modes contrived for doing all such things.”

“I don’t see how they contrive to keep the gunpowder from all flashing off at once.”

“I don’t know precisely how they do it,” said Forester, “but it would be easy to have a tube screwed into the end of the barrel, directly over the heated part, and then have a contrivance for dropping the gunpowder, a few grains at a time, down through this tube. Then if the part which contained the gunpowder, at the top of the tube, was closed over, so that the gases could not escape that way, they would all pass off through the barrel, and come up in bubbles through the water.”

“Now, by some such contrivance as this,” continued Forester, “the chemists have collected the gases which result from burning a certain quantity of gunpowder, and then, by pressing those gases into as small a space as the powder itself occupied before, they can tell what the expansive force is.”

“Yes,” said Marco, “I understand it, I believe.”

“The object,” continued Forester, “of all this, is, to measure the expansive power of the gases, and ascertain whether that power is enough to account for the explosive force of gunpowder.”

“And is it enough?” said Marco.

“No,” replied Forester; “the result of the experiment is, that the expansive force of the gases, which result from the burning of the gunpowder, when they are collected and artificially compressed, is not great enough to produce such powerful effects as are caused by the explosion of the powder.”

“Perhaps some of the gases escape,” said Marco.

“They have tried the experiment very carefully,” said Forester. “But there is one circumstance which makes the case very different, when the gases are collected in this manner, from the natural explosion.”

“What is it?” asked Marco.

“The gases,” replied Forester, “are in a very different condition, when they are first produced, from what they are when they are collected and compressed afterwards. When they are first formed by the burning of the gunpowder, they are intensely hot; but when they are afterwards collected and condensed slowly, they are cold. This must make a considerable difference in the force they exert.”

“Why?” asked Marco.

“Because,” said Forester, “any gas, when hot, expands with greater force than when cold. A bladder filled with air, will burst if you put it down before a hot fire. Steam, too, expands with vastly greater force when it is heated to a high

degree, than when it remains at the same temperature at which it was generated. So the gases resulting from the burning of gunpowder, when hot, will expand with much greater force than when cold. And when they are first formed by the burning of the powder, they must be intensely hot, from the heat produced by the combustion. So that, perhaps, that is the explanation of the force of gunpowder. Stated in general terms, it would be thus. The explosive force of gunpowder is owing to the sudden formation of a large quantity of elastic and expansive gases, at a very high temperature."

"Therefore," continued Forester, "the great thickness of the gun must be at the place where the gunpowder is lodged, as there the gases are first formed and most compressed. As the bullet moves along the barrel, the gases expand and fill the space, and so their force is diminished; but they still continue to act, though more and more feebly, pushing the bullet along until it leaves the muzzle of the gun."



CHAPTER VI.

TURNING AND BORING.

MARCO and Forester spent two or three hours in rambling through the water shops, and examining the various processes which were going on in them. They saw the place where the iron bars were rolled out, and cut into lengths suitable for forming the barrels; and Marco was astonished to observe with what facility the metal was worked by the help of the ponderous machinery. This was done at the lowest of the three dams. Here was also the stocking shop, as the workmen called it, where the stocks of the guns were turned. Marco was very much interested in this process, as, in fact, all visiters are. Turning is performed in an instrument called a lathe. The work to be turned is put into the lathe, and, by means of a wheel and machinery, is made to revolve rapidly. While it is thus revolving, the cutting tool is held against it, which cuts away the wood, or other material, all around the work. There is a part of the machine, made to steady the tool upon, which is called the rest. All kinds of work, which are round in one direction, such as round boxes,

knobs, handles, &c., can be fashioned in this manner much more easily, and much more correctly, than they can be by hand. Not only wood, but



brass, iron, and steel, can be turned in a lathe. The tools with which the harder substances are turned, are ground to a more obtuse angle, though equally sharp at the edge; and they are, of course, so adjusted, as to cut off only a small shaving at a time. Where the iron or brass work, which is to be turned, is very heavy, not only must the material be made to revolve by machinery, but the tool must be screwed firmly into the rest, as the strength of a man would not be sufficient to hold it. The rest, with the tool screwed into it, is made to move slowly along, so as to cut the metal away regularly, from one end of the work towards the other. Such a lathe as this, is called an engine lathe.

Marco saw several engine lathes. There were three or four in one room, for turning the gun-barrels. Marco watched the tool, as it moved slowly along the barrel, with a small shaving of iron running out continually from its edge, as the barrel turned over constantly against it. There was a little stream of cold water, which fell all the time upon the point of the tool. It came from a little pipe, suspended over the work. The pipe was connected with a small flexible tube, about three feet long, which came down from a long metal pipe, which passed across the room, over their heads, and contained a constant supply of water. The water in this pipe was raised, as Forester supposed, by a pump from the mill-stream. The end of the little pipe over the work was attached to the machinery, so that it moved along with the rest, and thus always delivered its little stream of water directly upon the edge of the tool, and upon the part of the iron which the tool was cutting. The flexible tube, or hose, as the workmen called it, allowed the pipe to be carried in this manner, along the barrel, from one end to the other, so as to pour the water continually upon the point where it was needed.

Marco wanted to know what the stream of water was for; and Forester told him that it was to keep the edge of the tool cool. The force of friction, produced by cutting so hard a material as iron, would soon heat the tool, and take the temper out of the steel—and then, the edge being

softened, would be immediately worn away. In fact, Marco observed, in many instances, that such streams of water were made to fall upon the work, where the cutting tool was exposed to heavy friction, in order to keep it cool.

The shavings cut off at each of the lathes, where the barrels were turned, fell into a box beneath. The workmen told Forester that these turnings were all worked up into solid iron again, and used for making more barrels.

"I should n't think that would be worth while," said Marco.

"Why not?" asked Forester.

"Because," said Marco, "they can only make a very little iron,—such thin shavings."

"We call them turnings," said the workman. "They amount to a great quantity. In fact, in finishing a gun-barrel, we take off more than we leave; so that if the trimmings and scraps were thrown away, more than one half the iron would be wasted."

Forester, as well as Marco, was surprised to hear this statement, but, on more particular inquiry, they were told that the barrel, in the rough form, weighed about ten pounds and a half, and that, when finished, it weighed only four pounds; so that considerably more than one half the quantity of material was cut away in the process of finishing.

One of the most interesting processes which Marco saw, was the grinding of the barrels after

they had been turned. It seems that although the tool by which the barrel is turned, is held and moved by machinery, which machinery remains precisely the same for a great many different barrels—still the barrels are not precisely alike when they come from the lathe. Some will be a very little thicker or thinner in some parts than others. Then, besides, the tool does not leave the iron perfectly smooth, for, as it moves slowly along at the same time that the iron revolves, it cuts in a spiral direction, round and round the iron, and leaves the work marked with a sort of spiral depression, left by the form of the edge of the tool. This has to be ground away, in order to make the surface of the barrel smooth and uniform throughout.

Now the manner in which it is effected, is this. An enormous grindstone, five or six feet in diameter, is made to revolve with great velocity, and a stream of water pours constantly upon it from a pipe above. This water would fly in all directions from the stone, on account of what is called the centrifugal force, produced by the rapid revolution of the stone, were it not prevented by enclosing the stone in a box, which confines the water. In front of the stone, and opposite the middle of it, there is a small opening through the box, large enough to admit the gun-barrel, and when it is in, there is a lever which may be pressed against it, to crowd it hard against the stone. The end of this lever, which is a smooth iron bar,

passes out in such a direction, as to come behind the workman, as he stands in the proper position for holding the barrel; and thus, while he holds the barrel in his hands, he can lean against this lever, and press the barrel with great force against the stone.

It is very evident, however, that if the barrel was held at rest in this position, while the stone was rapidly revolving, that it would only grind off a portion of it from one side, thus spoiling, instead of improving its form. In order to prevent this, and to grind it on all sides alike, the workman has an iron rod, with a crank handle upon one end of it. This rod he runs into the barrel before he applies it to the stone, and drives it in hard; and as the rod is made to fit the barrel, it holds it firmly by the friction. Then, by means of the crank at the end, he can turn the rod, and with it the barrel, and thus bring all parts of the barrel, in rapid succession, in contact with the stone. Thus, while the grinder was crowding back upon the lever, in order to press the barrel against the stone, he was at the same time turning the barrel constantly, by means of the crank, and thus the superfluous metal was ground off equally from all sides of the barrel.

So great was the velocity of the wheel, and the force with which the barrel was pressed against it, that Marco could see, by looking in at the place where the bar was inserted, that long sparks and streams of fire, struck out by the violence of the

friction, were continually darting down among the streams of water, which were descending all the time from the stone. It required but a very few minutes to grind the bar to its proper shape. The workman had a guage, or instrument for measuring the size of the barrel, at short distances, along its whole length. While grinding, he frequently drew it out to apply his guage, until he had reduced it to the proper size at every part.

In the same room with this machinery, there was another grindstone, with grooves in the circumference. This was used for grinding bayonets. The edges of the bayonets fitted into these grooves. The man who ground them, sat on a seat at one end, and held the bayonet against the stone. It appeared to be hard and disagreeable work. The stone revolved with great velocity, and so great was the friction, that a long stream of sparks flew out from the bayonet, whenever it was applied to the stone, although a stream of cold water was kept constantly pouring upon the place. The workman said that these monstrous stones, not unfrequently flew in pieces, on account of the swiftness of the rotary motion, and, in that case, some of the fragments would be sometimes driven through the roof of the building, or, perhaps, kill the workman seated at it. He said, however, that they had now an improved mode of securing the grindstone to the axle, by which this danger was very much lessened. In former times, they would put the stone upon the axle, and then secure it

in its place, by driving wedges in between the axle and the stone, which, of course, tended to split the stone, or, at least, to aid the centrifugal force in splitting it. But now the stone was secured by large plates of iron on each side, which were forced, by means of wedges, against the sides of the stone, thus securing the stone in a manner rather calculated to bind it together, than to force it open.

From the grinding room, they went into the boring and polishing room, though they found that the boring of the barrels, in fact, preceded the turning; and in order, therefore, to have seen the processes in their regular order, they should have seen the boring first, then the turning, and, finally, the polishing. When Marco saw the boring machinery, and was told what it was for, he said,

“But I thought that the barrels were made hollow at the forge.”

“Yes,” said Forester, “they are hollow, but they are necessarily left in a rough state, at the forge. The interior has to be bored out and polished, so as to make it smooth and true throughout.”

Marco advanced with Forester to the machinery by which the barrels were bored. They found that there was a solid iron frame, like a bedstead, a little more than twice as long as the barrel, on which were bars, and wheels, and rods, and systems of rack-work, too complicated for Marco to

understand. In the midst of all the machinery, however, there were one or two barrels, writhing, as if in pain, but neither revolving nor advancing. A long rod issued from each, and these rods were attached to wheels at the top of the frame. Marco perceived that these rods were revolving, and that the same machinery which caused them to revolve, was drawing them forward out of the barrel. He watched one of them until it came out, when he perceived that there was a sort of auger upon the end of it, by which it had bored its way through. The man then took another similar rod, with an auger upon the end of it, like the first, only it was a little larger; and, running it through the barrel, he attached the end of it to the proper machinery, at the head of the frame, and then set the works in motion again, by which the auger was drawn through slowly, but with great force, turning round and round all the time, so as to bore its way through,—the barrel writhing under the operation as before.

On another frame, at a little distance from this, other barrels were placed, and a different instrument, being of the form of a square steel rod, with sharp edges, was drawn through it, revolving swiftly all the time. This smoothed the interior, and removed all the marks left by the auger. Near these works there were some of the barrels that were finished,—that is, so far as the bore was concerned, and the workman held up one of them for Forester to look through. Forester seemed

much pleased with the appearance of it, and held it for Marco. Marco found, to his astonishment, that the interior was highly polished, reflecting a high lustre, and exhibiting a curious succession of concentric rings of great brightness. This resulted from some optical illusion, which even Forester said he could not explain. The workman said he did not know what caused the appearance of rings, as there was nothing, in reality, corresponding to them in the barrels—the bore being perfectly uniform and smooth throughout the interior. The outsides of these barrels were black and rough, just as they came from the forge. They had not yet been turned and ground.

Marco wanted to know why they finished the inside first.

“That is a general principle, in turning,” said Forester, “I believe,—to work from the inside outwards. If they should first turn and polish the outside, and then undertake to bore it out, it would be very difficult to get the bore exactly in the centre.”

“Well,” said Marco, “and suppose it were not exactly in the centre?”

“Then,” said Forester, “the barrel would be of greater thickness on one side than on the other, and it would be in danger of bursting on the thinnest side.”

“But,” said Marco, “they might make it so thick, that even the thinnest side would be strong enough.”

“True,” replied Forester, “but then all the extra thickness on the other side would be of no use. It would only add to the weight of the gun, without being of any service; for the gun could not be charged any more heavily than the strength of the thinnest part would bear. Therefore, to combine lightness with strength, in the greatest degree, it is necessary to have the thickness of the barrel the same all around, and to have this thickness diminish towards the muzzle, exactly in proportion to the diminution in the force of the gunpowder, as the ball moves along from one end to the other. Then the barrel would be equally strong throughout, and not more likely to burst in one place than in another.”

“Very well,” said Marco, “I admit that; but I don’t see why they cannot finish the outside first, and then make the bore to correspond with that, as well as to finish the bore first, and then turn the outside to correspond with the bore.”

“It is because,” said Forester, “they can’t control the boring as well as they can the turning. The boring tool must be long and slender, in order to be passed through the barrel, and of course it will easily spring, and yield somewhat. If the outside of a cylinder were to be turned true, and fixed precisely in the centre of the motion of the lathe, and then if a drill could be made absolutely inflexible, it would run through the centre. But it is impossible to realize these conditions.”

“I don’t know what you mean by realizing conditions,” said Marco.

“Why, making the circumstances such as I have supposed. The drill will yield and spring a little, especially if the cylinder is already hollow, and is only to be bored out more, and made true. The inequalities in the interior will force the drill or auger to one side or the other, and thus render it impossible to control the boring. But after the boring is finished, then the barrel may be set in the lathe, and chocked by the bore.”

“Chocked by the bore?” asked Marco.

“Yes,” said Forester; “that is, the pivots on which it turns may pass into the bore, and as the pivots are precisely in the centre of the motion of the lathe, the bore will be so too, and then the outside can be turned to correspond. Because you see that on the outside there is plenty of room, and the tool can be made very massive and solid, so as to have no sensible spring. The reason why the boring tool cannot be made inflexible, is, that it must be long and slender in order to pass into the bore. There is not room for metal enough to make it firm and unyielding. Therefore, in turning, it is generally best to finish the hollow part first, and then to make the exterior to conform to it.”

At this moment Marco’s attention was attracted by a curious appearance at one end of the room, and he advanced with Forester to see what it was. It proved to be the machinery for polishing the

outsides of the barrels after they were ground. It appeared that the barrels, after being bored, as Marco had seen, were carried into the other shop to be turned and ground on the outside, and were then brought back to be polished in this shop again. There were two machines for polishing, and each had four gun barrels in it. The form of the machine was an upright iron frame, and the barrels were placed in it in a perpendicular position. The upper ends were attached to wheels, by which they were kept in constant revolution, and these wheels were also attached to a beam which ascended and descended continually, like the beam over the piston rod of a steam-engine, or that which carries the saw in a saw-mill. Thus the barrels were alternately drawn up and pushed down, continually revolving at the same time. They passed in this manner between a set of leather cushions, covered with oil and emery,—a fine powder used for polishing. These cushions were pressed together by springs, with the barrels between them, and thus all the roughness of the iron, left by the grindstone, was gradually worn away, and the barrels came out at last highly polished.

The smaller parts of the musket, such as the screws, bands, and parts of the lock, were polished in a different manner,—by holding them one by one against wheels, revolving with great velocity, as Forester had said. There were a great many of these wheels in one of the rooms,

with workmen seated before them polishing small pieces of steel work. One of the workmen said that the wheels revolved from twelve to fifteen hundred times per minute. This would be about twenty times in a second. Marco tried to whirl his hand around in the air as swiftly as he could, but he thought that he did not succeed in making more than two or three in a second. Long streams of sparks issued from the emery wheels when the steel was brought in contact with them.



CHAPTER VII.

INSPECTION.

IN an apartment connected with one of the water-shops, Marco and Forester saw an operation going on which was very different, in its very nature, from all which they had seen before. It was the operation of testing the work after it had been performed. The testing which they saw, was that of the bayonet. A pile of bayonets lay before a workman on a bench, and he was trying them, to see whether they were of the proper temper and strength.

The manner in which he tested the bayonets, was this. He put them, one by one, upon a gun, and then, striking the point a little into the floor, he would spring it forcibly one way and the other, to see if it would bear the necessary strain. By this operation, the bayonet was bent a little to one side or to the other. This was called *taking a set*. A piece of steel, or iron, or brass, or any similar metal, may be bent a little out of its natural position, and it will spring back again, so as to take precisely the form which it had before. If it is bent, however, a little too far, it will not come

entirely back, but will remain bent. This is called taking a set. Steel, highly tempered, may be bent much more, without taking a set, than brass or iron. This makes it suitable for springs. Its elasticity is so great that it will restore itself entirely from a very considerable flexion.

The more highly tempered steel is, the less easy it is to make it *set*, but then, the more brittle it becomes. A file is very highly tempered, and it cannot be set at all. If sprung a very little from its proper position, it will spring back again entirely. If sprung more, it will break,—but it cannot be bent so as to remain bent.

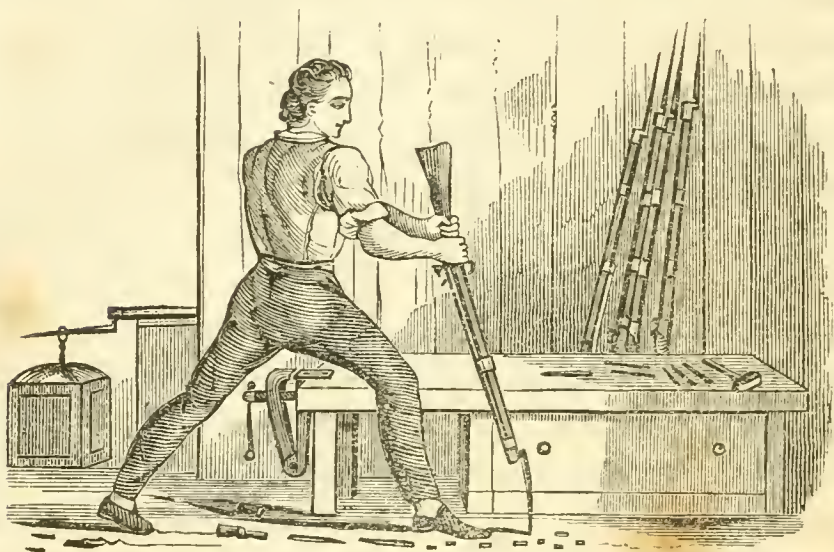
A saw, on the other hand, is not tempered so highly, and it may accordingly be bent so as to take a set. Saws often get so bent, by being carelessly used, and thus they become crooked. But by being thus tempered not so high, they cannot be so easily broken. A saw will not snap off suddenly like a file, but, bent beyond the point from which the steel is capable of restoring itself, the particles will yield a little, and thus it will take a set. Now, though it is an evil for a saw to take a set, since it makes it crooked, it is a greater evil for it to break in two,—and therefore it is tempered in such a manner as to bend a little, rather than break.

It is the same with the bayonet. It is desirable to have it elastic,—but then it must not be brittle. The workman tested the strength of the bayonet, by springing it forcibly with the point upon the

floor, in the manner which has been already explained. He tested its elasticity in another way, which seemed to Marco very ingenious. There was a place fitted at the end of the bench, where he could rest the neck of the bayonet upon a solid support, which seemed as a sort of fulcrum. The point of the bayonet was then inserted into a loop in a wire, which had attached to the lower end of it a heavy weight of lead. Then, by bearing down upon the end of the gun, the lead was lifted, the whole weight of it resting upon the point of the bayonet. This weight was so heavy that it bent the bayonet down an inch or two, and when it was let down again, the bayonet would spring back nearly into its place, but not quite. It *set* about a quarter of an inch. The man who was examining the bayonets, said, that if they did not set more than a quarter of an inch in lifting such a weight, they were considered as passing a satisfactory trial in respect to their elasticity.

After watching the process of testing the bayonets in this manner, for some time, the workman opened a box which was under the bench, and showed them some which had been condemned. One was broken in two in the middle, not having had strength sufficient to bear the violent strain which the workman had given it, with the point upon the floor. Marco took up the fragments and examined the fractured surface, to see if he could discover the cause of its breaking. There was a small discolored spot, visible near one edge, which

was caused by a flaw in the iron. Another bayonet was whole, and Marco could not see why



it was condemned. The workman, however, pointed out to him an imperfection in the corner, where the blade of the bayonet joins the neck.

“Whose loss is it,” said Forester, “if the blade is condemned?”

“If it is owing to the workmanship,” said the man, “it is the loss of the man who made it. But if it arises from any flaw in the iron, he does not lose it.”

“And is most of the work done by the piece?” said Forester.

“Yes,” replied the man; “and if it does not stand inspection, the man loses it.”

Marco did not understand this conversation very well, and he asked an explanation of Forester after they had left the shop. Forester told

him that paying by the piece, was paying in proportion to the work done. "For instance, if a man is forging bayonets," said he, "paying him by the piece, is giving him a certain sum for all the bayonets he makes."

"And what other way is there?" said Marco.

"Why, they can be paid by the 'time," said Forester,—“so much for a day's work, for example, whether they accomplish more or less.”

"I think it is better to pay by the piece," said Marco.

"Certainly," replied Forester, "when the work is of such a kind that it can be accurately measured."

"Well," said Marco, "and cannot all work be accurately measured?"

"No," replied Forester; "for instance, mending the roads in the spring, after they have been washed by the rains, cannot be measured. There will be much more injury done in some places than in others, and the facilities for getting materials and repairing the injuries, will vary much in different parts of the road. Then, besides, there would be no way of deciding when the work was properly done. A very accurate test of the elasticity of a bayonet can be applied, by requiring that it should lift a certain weight, without setting more than a quarter of an inch. But there would be no mode of ascertaining precisely how much should be done to the road. Therefore, persons

employed in mending the roads, must always be paid by time."

"In almost all kinds of manufacturing establishments, however," continued Forester, "they can estimate most of the work exactly, and, accordingly, they contract with the laborers to pay in accordance to the work done. This is altogether the best mode, and they always endeavor to adopt it, especially in all great establishments, where the men would be very likely to be idle if they were paid by the time. It would be so, more particularly, in a government establishment, like the Springfield armory."

"Is the Springfield armory a government establishment?" asked Marco.

"Yes," replied Forester, "it all belongs to the government of the United States. It is intended solely for manufacturing muskets for their armies. The government have built the shops, and put in the machinery, and they employ the workmen to do the work, and pay them all according to the work they do, provided it is done so well as to pass inspection."

"Why is it more important," asked Marco, "for a government to employ its men to work in this way, than for a private individual?"

"Because," replied Forester, "if a private individual employs persons to work for him, and is going to pay them by the time, he can oversee them himself, and know whether they are industrious or not. But a government cannot do this

It cannot be present itself, but must act through agents ; and agents are never so faithful as principals. Therefore, governments and corporations always avoid paying men by time, if it is possible to systematize the work so as to measure it, and to pay in proportion to the work done."

"What are corporations?" asked Marco.

"Where a large number of men combine to carry on any great enterprise in common, they form an association, called a corporation. Now a corporation, like a government, cannot be present to oversee its work. They must employ agents, and they, therefore, are very reluctant to employ men and pay them by the time. Rail-roads are commonly made by corporations, and they are very unwilling to pay laborers by the time that they are employed. A great deal of the work which they do is grading the road, which is a very difficult kind of work to measure, because it consists of digging away, or filling up very irregular pieces of ground; still they take pains to measure it, and employ men to do it, by paying them so much per square yard for all that they remove."

"Is there any other kind of work," said Marco, "which they cannot estimate, so that they have to pay by time, as they do for mending the roads?"

"Yes," said Forester, "all kinds of farm work. If a farmer hires men to work upon his farm, he pays them by the time they labor,—by the day, the month, or the year. He cannot pay by the

work done, for the work is so irregular and variable, that it cannot be measured or estimated."

"Why, he might pay them so much," said Marco, "for hoeing so many rows of corn, or for ploughing so much land."

"No," said Forester, "for the work of hoeing and ploughing will vary exceedingly, according as the ground is hard or mellow, or more or less encumbered with stones and weeds. Then a great proportion of the other work on a farm, it would be still more difficult to measure. Therefore, a farmer, if he hires a laborer, must pay by the time. This is one reason why men cannot well carry on a farm to advantage by hired labor. They cannot measure the labor, and pay for it, according to the amount of work which is done. Still, the farmer has one great advantage, which the corporation has not. He can work with his men and oversee them all the time; and when working with him, in his presence, they are much more industrious and faithful. But if a man undertakes to manage a farm by hired laborers, without laboring with them himself, the difficulty becomes very great. He almost always fails in his experiment."

"I saw one man," said Marco, "in one of the shops, who was making little screws. They were the little screws used in making the lock. He said there were seven different operations to be performed on each screw, and that each one had a

separate machine for performing it; so that it took seven engines to make one little screw."

"Yes," said Forester, "and not unlikely each engine may have cost a hundred dollars."

"And there was the forging, besides," said Marco.

"Yes," said Forester; "so that, perhaps, five hundred or a thousand dollars may be invested in machinery, all of which is necessary to make one screw. This would be an expensive way if only one screw was required,—but when they have so many to make, it is the cheapest way, because, by means of all this machinery, they can make them very fast. And that is not the only advantage. They can not only make them fast, but by being made in machines, they are all precisely alike. This is a great advantage; for they can send some spare screws with muskets when they go into the army, and then, if one gets lost or broken in any lock, they can at once replace it. Any one of the spare screws will exactly fit the place of the lost one."

"Or if two locks get broken," said Marco, "in different places, they can put the parts of one with those of the other, and so get one good lock out of the two."

"Yes," said Forester. "There is one inconvenience in having machinery to make all these parts of the musket, and that is, that they cannot make any change in the pattern of the musket, without a great expense; for all machinery which

was adapted to making the parts according to the old pattern, becomes useless, and they must construct new and expensive engines to correspond with the new pattern. So it becomes a great work to introduce any new and improved modes of construction."

During this conversation, Marco and Forester had been walking slowly along toward the high land, where the finishing shops of the armory and the store-houses were, around the great square, on the plain above Springfield, as explained in the third chapter. By this time these buildings appeared in sight, and our two travellers advanced towards them, much interested to know what new objects of curiosity they were to find in this part of the establishment.



CHAPTER VIII.

THE ARSENAL.

THE first building to which Forester conducted Marco, at this part of the work, was near the north-west corner of the square. On entering it, they found a very long, spacious apartment, with a double row of forges extending through the middle of it. The floor was paved with flat stones. The walls and ceiling were neatly whitewashed. Over each forge was a pair of blacksmith's bellows. There were men working at several of the forges, and Forester and Marco advanced to see what they were doing.

Instead of the simple anvil and hammer, used by blacksmiths for common work, they found that much more complicated apparatus was used here. There was at each forge a large anvil, but the surface, instead of being flat and level, as usual with anvils, had upon it a variety of depressions and perforations; and there were also by the side of each, what Marco was disposed to call little anvils, but which the workmen told him were called *stakes*. These stakes had excavations and depressions sunk in them, of various irregular forms,

the use of which Marco did not at first understand.

At the first forge to which Marco approached, a workman was heating the end of a long iron rod. When it was heated, he put it over one of these stakes, in such a manner that the hot iron would lie in one of the depressions. There was another piece of steel placed over the stake, and supported in a peculiar manner, which could be struck with a hammer from above, and driven down upon the stake. This was called a jumper; for it would jump up in a curious way after it was driven down. Now there was a depression in the under side of the jumper, corresponding to the one on the upper side of the stake, in such a manner that when the two were brought together, a cavity was left between them, of such a form as that the piece which they were going to forge would exactly fit into. By this contrivance, it was easy to forge the most irregular parts of the gun-lock. They had only to heat the end of the iron rod, and insert it while hot, between the stake and the jumper. Then by striking repeated blows upon the jumper with the hammer, the hot metal would be spread into the cavity between them, in such a manner as to take its exact form.

In some cases it was necessary to perform more than one operation upon the same piece. One part would be formed between one stake and jumper, and then it would be heated again, and the other part fashioned by another. The stakes,

and jumpers, and other similar apparatus, were, of course, all different at the different forges ; each



forge being designed for some particular part of the lock. At some forges the work was making screws ; at others springs ; at another, what was called the tumbler, which is a part of the lock, of a very irregular shape. Marco was very much interested, to see how easily all these various forms were produced by means of these contrivances.

From this forging shop they went to other large buildings, where various operations, connected with finishing the locks and guns were going on. In one room men were employed in smoothing over the gun-stocks, taking them as they came from the lathes in the stocking-shop. Others were fitting the locks to the stocks, or rather, cutting away the wood in such a manner

as that the locks would fit. They went into one long chamber, with benches all around it, where workmen were employed in filing and finishing the small parts of the lock, which they had seen forged in the forging shop.

In this apartment, Marco observed that each bench seemed to be fitted for one particular branch of work; and it had its vice, its tools, and its patterns, adapted to that, and to that alone. The patterns were made of steel, and the workmen filed the work to correspond with them exactly. Here each man was employed in finishing a great many pieces of the same kind, and he made them all as exactly alike as possible.

In one part of this room a man was engaged in putting these pieces together, to make the locks complete. He had a long box before him, divided into many compartments. These compartments had the several parts of the lock in them, a great many of one kind being in each part. The workman would take up one of each kind, and put them together to make a lock. In doing this, he had to file them down a little sometimes, to fit them exactly to their places. If the holes which the screws were to go into, were not quite large enough, he would bore them out larger, and Marco was astonished to see how easily he would cut and bore the solid brass and iron. It took but a very short time to put one set of the parts together to make a lock.

As they walked away from this place, Forester

said that it afforded a very fine example of what was called division of labor.

“What is meant by that?” said Marco.

“Why, you see,” replied Forester, “that in making a lock, they divide the work into a great many parts, and give each man only one small part to do. They construct tools and instruments expressly for that part, and as the man has nothing else to do, he acquires great expertness in doing the particular thing assigned him. The other plan would be to let each man be employed in making a whole lock. In that case the work would be done to great disadvantage; for, in the first place, each man must have a complete set of fixtures and tools for all the different kinds of work, and then he must constantly change from one kind of work to another, and thus lose time; and then, by having to learn a great many different kinds of work, he could not be so skilful in any. But, on this plan, each man has only to learn one or two operations, and these he learns perfectly, and he naturally falls into such operations as he has the most natural talent for.”

“I never heard of natural talent for work,” said Marco.

“There is talent for work,” said Forester. “Men have different talents or capacities for different kinds of mechanical works. One man has excellent success, for example, in tempering edge tools. He has a certain nice power of perception, which enables him to regulate the process exactly,

and temper the steel at precisely the right heat. Another has not that peculiar quickness of eye for this, but has a good capacity for judging of *form*; and so he makes a good filer. He will file a piece into the true shape, in a much shorter time, perhaps, than the one who is so skilful in tempering. There is as much variety in the bodily system as there is in the mental, and it makes as great a difference in the powers and capacities of men, in regard to their fitness for different mechanical pursuits, as the difference in intellectual genius makes in their fitness for the professions, or other mental employments. I have heard it said, by printers, that some men can never make rapid compositors."

"What are compositors?" asked Marco.

"Those that set up the types," said Forester. "Composing, is setting types. The compositor has the copy before him, and a box inclined towards him, like a desk, with small partitions in it, and each compartment has one kind of type. Now the compositor looks at a word, notices the letters, and then takes them up one by one from the various compartments. The philosophy of it is this. The image of a letter in his eye produces an effect on the nerve, which is communicated to the brain, and thence to his mind. Then there arises in his mind an idea of the compartment where that letter belongs, and the nerve leading to the arm produces the proper motion to carry the hand to the proper compartment. You

see it is, in fact, quite a complicated process,—partly bodily and partly mental. Now this process is completed much quicker with some persons than with others. It is owing to some peculiar and hidden difference in the nerves, or brain, or muscles, by which the mechanism in some cases acts quickly, and in others more slowly. But those persons in whom these nervous communications are made more slowly, are not necessarily inferior to the others, for they may have the advantage in some other power of body or mind, which more than counterbalances this. For instance, one person may hear or see quicker than another; but the second may hear *more correctly* than the first. One may have such a bodily constitution, that his sense of touch is very nice—another has correct ideas of form, another of sounds, and thus all vary. Thus, different workmen are fitted to different processes and employments; and by adopting the system of division of labor, each after a time falls into the one which is most adapted to his powers; and so he works to the greatest advantage in doing always what he can do easiest and best.”

Not long after this, Forester and Marco went into the central building, on the main front of the square, which Forester said was the office and counting house, and asked a gentleman, who was there at a desk, if they could go into the arsenal. The arsenal was one of the large buildings where the muskets were stored after they were finished.

They had been told by some of the workmen that the arsenal was locked, but that if they went to the office, a gentleman would go with them, and let them see it. As there was nobody at work in the arsenal, it was customary to keep it locked. The gentleman in the office said he would go with them; so taking a key, and putting on his hat, he followed them out.

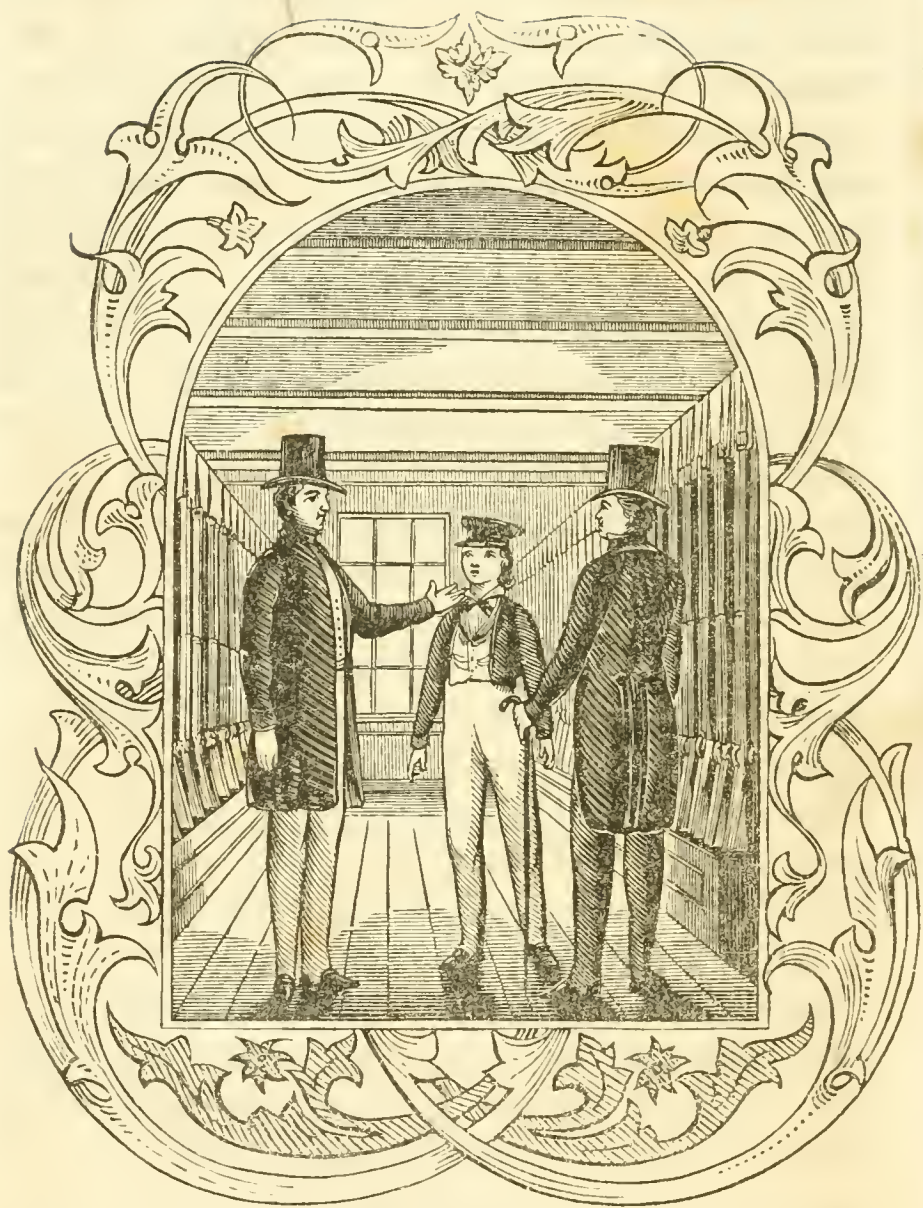
He conducted them along a gravel walk, which led between two rows of trees, toward the centre of the square, and after advancing for some distance in that direction, he turned at right angles into another walk, which conducted them across that part of the square, towards the front door of the arsenal.

He unlocked the door, and ushered Forester and Marco into the apartment. They were both struck with astonishment at the imposing spectacle which was presented to their view. Except the necessary space for passages, the room was entirely filled with muskets. They were arranged, with the most perfect precision and symmetry, in an upright position, the butts resting in frames made for the purpose, and raised at a little distance from the floor. The tops of the bayonets reached nearly to the ceiling. The dark and glossy brown color of the stocks, with the highly polished lustre of the bayonets, and other metallic parts, gave to each individual gun a very beautiful appearance; but, in addition to this, there was a most surprising effect produced by the immense numbers and

admirable arrangement of the whole. The rows of bayonets glittered in a long perspective. Even the locks, and the ramrods, and the sights upon the barrels, and, in fact, every single part of the gun, were presented to the eye, in long ranges, extending up and down the room. The guns were placed on the frames, only about half an inch apart, and yet so precise was the arrangement, that, by standing at one end of the room, and looking through, Marco could see the window at the other end, through any one of these crevices, at a hundred and twenty feet distance, which was the length of the room. The room was a hundred and twenty feet long, and forty feet wide; and there was another in the second story, of the same dimensions, and filled in the same manner.

Forester asked the gentleman, who conducted them to the arsenal, how many muskets there were in the building; and he said, nearly a hundred thousand. These were all ready for use. They had to be taken down and oiled, he said, every few years, to keep the bright parts from rusting. They could be very easily taken out of their places, as they were not fastened in, in any way. The gentleman took one of them out, to show how easily it could be removed.

After admiring this beautiful spectacle a few minutes, Forester and Marco thanked the gentleman for his kindness, and went away. As they had now completed their survey of all the shops and buildings, they left the grounds, and went down into the village of Springfield to their hotel.



"They were both struck with astonishment at the imposing spectacle which was presented to their view."—See page 104.

CHAPTER IX.

THE DANGER OF BEING ARMED.

WHEN Forester and Marco had finished their examination of the armory, Marco began to consider, in pursuance of the plan which Forester had adopted, of allowing him to have the whole direction of the journey, what arrangements he should make for going to Boston. He decided, at once, to go by the western rail-road. He knew very well that the great western rail-road from Boston to Albany, passed through Springfield; and he very naturally inferred, that he could take the rail-road, and go directly to Boston. He asked what time the cars came in, and they told him about noon. He accordingly made arrangements to have a carriage take them to the depot at that time.

There was one thing very excellent in Marco's travelling arrangements, and that was, the principle of always being in ample season. On this occasion, they reached the depot about twenty minutes before the usual time for the cars to arrive, and while they were waiting there, seated upon a settee in the gentlemen's room, they spent the time in conversation.

Marco had been very much interested in the admirable system and order which prevailed in all parts of the armory; and he had been astonished at the vast accumulation of arms, which he saw must exist in the arsenals. After conversing with Forester on various other topics, he began to talk about this; but Forester did not appear to take much notice of what he said.

“It must cost a great deal of money,” said he, “to make such an immense number of muskets.”

Forester did not answer.

“And it must take a great deal of time and trouble to keep them all safe and in order.”

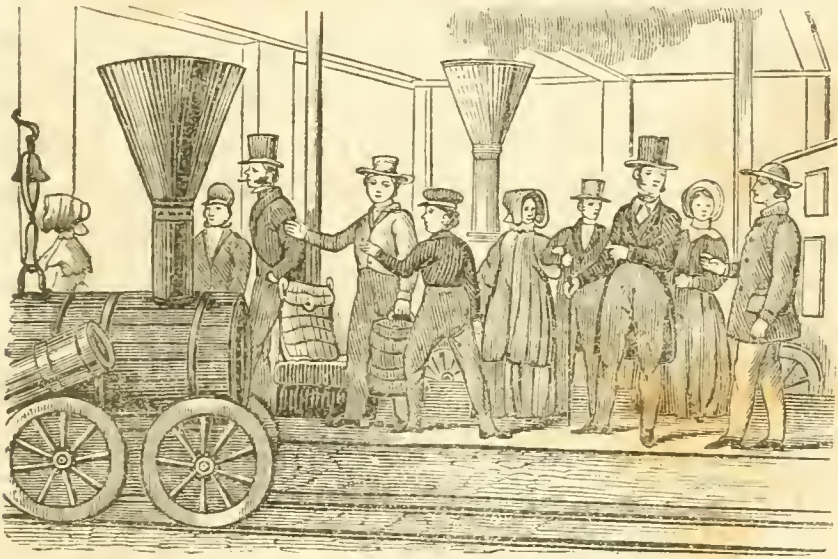
Forester said, “Yes,” faintly; but yet he seemed to be thinking of something else.

“But I think it is an excellent plan,” said Marco, “notwithstanding; don’t you, cousin Forester?”

“Cousin Forester!” repeated Marco, when he found that his cousin did not answer; “don’t you think it is a good plan to make all these muskets? and then when the enemy comes to fight us, we shall be ready for them.”

“Why, to tell the truth,” said Forester, “I was thinking of something else. Let me see your tickets.” Marco had gone, when they first got to the office, and bought two Boston tickets, one for himself, and one for Forester. Marco handed these tickets to Forester. In the mean time, the bustle in the great house, close adjoining the

office, had been for some minutes rapidly increasing. Heavy trains of cars moved slowly one way or the other; sometimes pushed by men, and sometimes drawn by a locomotive. Passengers were coming and going in considerable numbers, and at this moment a bell was heard to ring. A conductor also came to them, and asked them which way they were going.



“On the western rail-road,” said Marco, promptly.

“The western cars are ready,” said the conductor.

So Marco and Forester rose, and Marco led the way towards the cars—Forester and the conductor following. Marco heard them talking together about something, on the way, but he could not tell what, on account of the noise and bustle which

surrounded them; and presently they took their seats comfortably in the cars.

Now Marco unfortunately forgot, that, though the rail-road between Boston and Albany is all called the western rail-road, at Boston, yet at Springfield, a part of it extends towards the eastward, and it was this eastern part which he ought to have taken, in order to be conducted to Boston. But as Marco said that he was going on the western rail-road, the conductor supposed that they were going to Albany, and he put them into the western cars accordingly; so that as soon as the train began to get fairly under way, Marco was carrying the party under his charge, at the rate of twenty miles an hour, in a direction exactly contrary to the one in which they wanted to go.

Forester understood all this, but made no explanation, and so they went on. After a few minutes' pause, he said,

“You were asking me, Marco, about the wisdom of manufacturing all these muskets.”

“Yes,” said Marco, “so as to have them ready.”

“I don't know myself,” replied Forester, “whether it is a good plan or not. It takes a statesman to judge safely about measures for the defence of nations. But as far as I can see into the subject, I should think there was some doubt about it.”

“Why?” asked Marco.

“It generally makes *men* quarrelsome to go

armed," said Forester; "and I didn't know but that it might possibly have the same effect among nations. In some countries it is the custom for almost every gentleman to carry some deadly weapon about him—as a little dirk or dagger, or a pistol; and in such countries, quarrels, and murders, and assassinations are generally very frequent."

"What countries are they?" asked Marco.

"Why, this was the practice in almost all countries, a century or two ago, I believe," replied Forester; "and the custom continues to this day, in some places. It is so in the southern states, I'm told, particularly in New Orleans,—and, either for that reason or some other, there are a great many quarrels, duels, and murders there. In New Orleans, a great many persons wear dirks, or bowie-knives, or pistols, ready to pull out at a moment's warning; and this makes them fierce in spirit, boastful, and revengeful."

"But then," said Marco, "they know that everybody else is armed, and I should think that that would make them keep civil."

"No," replied Forester, "it does not have that effect. Each one has an exaggerated idea of his own skill and power, and thinks that, in a fight, he should come off conqueror; and so he is always ready to give provocation and to resent provocation. But, in Boston, nobody goes armed, and serious quarrels are very rare."

"You can easily see how it must be," contin-

ued Forester, "by the case of boys. Suppose fifty boys were amusing themselves upon a green; and while they were there engaged in playing ball, or some other peaceable sport, suppose that a pedlar should come along with a bundle of little whips, fifty in the bundle, and the boys should each buy one, and then go back to their play; it is very easy to see that there would probably soon be difficulty."

"Yes," said Marco, "I suppose there would."

"The boys," continued Forester, "would run about, snapping and brandishing their whips at one another, in a threatening manner. In fact, the very possession of a whip would produce a sort of instinctive desire to use it, and it would be very likely, that although they might all have been very peaceable and harmonious before, there would several serious quarrels arise out of this unlucky arming of themselves with whips."

"Yes," said Marco; "whips are very apt to make difficulty among boys."

"Now it is somewhat so with men," rejoined Forester. "When a man gets a new patent revolving pistol, which will discharge six bullets in as many seconds, the possession of it awakens a sort of desire to try it. 'There,' says he to himself, 'I should like to see a robber attack me now;' or 'if anybody wants to insult me now, let him come on.' Thus his mind assumes a belligerent attitude, ready to take offence at any provocation."

"What is belligerent?" asked Marco.

“Warlike,” replied Forester.

“Now I think it probable,” continued Forester, “that it is somewhat so with nations. If a government has just finished some very superior ships of war, or has got an immense army all finely organized and armed, I should think it likely it would not be quite so patient and forbearing as it was unarmed. At any rate, I am quite sure that if all the nations would disband their armies, and destroy their stores of arms and ammunition, reserving only an amount of physical power sufficient to preserve internal order, the peace of the world would be much more secure than it is now. Everybody admits this; but then they say that the nations generally will not do this, and that it is not safe for any one to go defenceless while the rest are armed.”

“So I should think,” said Marco.

“I am not certain about that myself,” said Forester. “If a Boston traveller goes to New Orleans, he does not arm himself, but passes to and fro, among the dirks and bowie-knives, as safe as any of those that are armed. He is not as safe as he is in Boston; but he is safe as any man can be in a community where he is so surrounded with deadly weapons.”

“If I was going to travel among *robbers*,” said Marco, “I should certainly get some pistols.”

“Why, even that would be doubtful,” said Forester. “If you were attacked, it is very likely that pistols would do you more harm than good.”

“How?” asked Marco.

“Why, not being used to fights and firings, you would feel a kind of excitement and trepidation, and would not act coolly enough. Perhaps you’d fire too quick—before you had taken proper aim; or else you would wait so long, that, while you were aiming, the robber, seeing that you were going to try to shoot him, would shoot you, or cut you down with a sword; whereas, if you had offered no resistance, he would probably only have robbed you, without taking your life. To shoot a defenceless man, is very easy,—but to shoot a robber, who comes up to attack you, completely armed himself, and on the alert, is very difficult. It requires great coolness, steadiness and precision, to act in such a case exactly right, and exactly at the right instant. And then, if you exercise all this coolness and firmness, and act exactly right, and shoot one robber,—ten to one there will be another, or a gang of them, who will immediately blow your brains out, in revenge; whereas, if you had been unarmed, they would probably have only taken your money, and let you go.”

“No,” said Marco; “I think they would kill me.”

“I think not,” said Forester. “Robbers seldom murder those whom they rob, unless they think they are compelled to do it on account of the resistance they make, or for some other cause.”

“Well,” said Marco, “I suppose if there was a

gang of them, it would n't be of any use; but if there was only one, I think I could shoot him."

"You might possibly," said Forester; "but even that would injure you more than it would him; for if you should succeed in wounding him badly, it would be a horrid sight, to see a wretched man writhing in convulsions on the ground, and biting the dust in agony; and it would be a great many years before you could get it out of your mind. It would make you gloomy and miserable while awake, and visions of it would terrify you in your dreams. The indignation and anger which you felt when you shot at him, would be changed into pity and compassion for him when you saw him in misery. Perhaps he would linger several days in extreme suffering, and you would watch him and inquire after him day after day, and wish that death would come and put an end to his pain. You would begin to imagine excuses for him. You would think that perhaps he had been neglected when a boy, and had never been taught to be honest and true,—or that he had a wife and children perishing for food, and that he had no way of earning a supply for them. These thoughts would add to your anguish; and you would perhaps wish that you had given up double the sum that he would have taken from you, rather than to have shot him. Even if your sense of his guilt remained unchanged, and you were satisfied that he de-

served to die, you would wish that you had left it to somebody else to be his executioner."

Marco said nothing in reply to these remarks. The view of the subject, which Forester thus presented, was new and unexpected to him. He saw, however, very plainly, that it was a correct one, and he was rather inclined to come to the conclusion, that if a traveller was so unfortunate as to be compelled to choose between the two evils of suffering a robbery or committing a homicide, it would be best, on the whole, to submit to the former. At any rate, he saw very clearly that Forester would rather be robbed than shoot a robber.

"However," said Forester, at length, "to return to the subject; I think it is best for an individual to go unarmed, whether other people do or not. But in regard to a nation, the case is very different, in one respect, at least; and so I don't decide that question."

"In what respect is it different?" asked Marco.

"Why, when an unarmed individual is among others that are armed," said Forester, "at New Orleans, for example, he has the laws of the country to protect him. There are courts and officers of justice, which have all the individuals in the community under their control, whether armed or unarmed; and these powers of government preserve the peace and protect the defenceless. If a defenceless man is attacked in the street at New Orleans, he has only to call out 'watch,' and there

are plenty of men ready to run to his rescue, fully empowered to protect him, if it is possible to do it. But nations have no such system of general law and government over them. There is a general system of law, commonly recognised and acknowledged, called the law of nations; but there is no government to execute it. Every nation has to execute the law of nations for itself. If a man in New Orleans concludes no longer to go armed, and throws his pistol into the Mississippi, he does not, by any means, throw away all the physical protection he has. He still reserves his claim to the force of the police and the officers of justice, who stand always ready. But if a nation were to disband its armies, and destroy its arms and ammunition, it would give up the whole—for there is no power above it to help it, where it cannot help itself. This makes the case of nations essentially different, and I don't know enough about it to judge what the effect would be of a nation giving up its defences in time of peace. One thing I know, and that is, it would save an enormous expense by doing so, and it seems to me that what it would save in time of peace, would be of more use in money, in case a war should break out, than what was left of the preparations they had been making; for a great deal of the amount expended is lost and consumed year by year, and does no good. Then the way of constructing arms, and ships, and forts, changes from time to time, and thus many expensive pre-

parations become useless, by being superseded, before they can be used. If I could meet with some intelligent politician, I would ask him what amount our government has expended for warlike preparations, since the last war, and what it is all worth now."

Marco said that he should like to know very much, and then asked Forester what time he thought that they should get to Worcester. He knew that Worcester was between Springfield and Boston, as any of our readers can see by looking upon a map.

"I don't know," said Forester. "I think it is very doubtful when we shall see Worcester again."

"Why, how far is it to Worcester?" said Marco.

"From here," said Forester, "and in the way we are going?"

"Yes," said Marco.

"If we keep on always in the same course by the compass, it may be about fifteen thousand miles; but if we go in a straight line, about twenty-four thousand. It would be just once round the world, minus fifty miles!"

"Round the world!" exclaimed Marco, in astonishment.

"Yes," said Forester, coolly. "Worcester is east from here, and we are going west. These cars are going to Albany."

Marco started up in amazement, and was going

to run to the conductor, to get him to stop the cars, but Forester advised him to sit down, and keep quiet. He then explained to him the cause of his mistake.

“And why did not you tell me before?” asked Marco.

“Because,” said Forester, “I thought it would be a good joke, and that you would n’t care much. We can go to Vermont through Albany as well as through Boston. It was only by mistake that we got into Massachusetts at all, and now, by this second accident, we shall get back again upon our original route.”

“Yes,” said Marco, “only my tickets won’t do; I bought Boston tickets.” So he began to feel in his pockets for his tickets, but Forester told him that he need not trouble himself about them.

“When I saw,” said he, “that you were coming into these cars, I handed the tickets to the conductor, before we got in, and he exchanged them for me, and gave me checks, and here they are.”

After Marco had in some measure recovered from his surprise, he asked Forester what he meant by saying, “that if they went round the world one way, it would be fifteen thousand miles; but if they went in a straight line, it would be twenty-four thousand.” “But I should think,” said Marco, “that going in the same course by the compass, would be going in a straight line.”

“No,” said Forester; “going by the compass, is not going straight, except in some particular

cases. If we set out to go exactly west from here, we should go round the world on a parallel of latitude, keeping always at the same distance from the pole. But if we keep on in the same absolute direction, we should go round upon a great circle, and thus pass entirely round the world."

"I don't understand it very well," said Marco.

"I can make it very plain," said Forester, "with a globe. I will show you, when we have an opportunity to see a globe."

Just then the cars began to go slower, and presently they stopped at a little village, where an orange girl came in with a basket of oranges for sale. Forester bought two,—one for Marco, and one for himself; and he made Marco's, which was the biggest, answer very well for a globe, so far as was necessary to explain to him the difference between going round the world on the forty-second parallel of north latitude, which is about the parallel that they were then on, and going on a great circle. The one would keep them on the north side of the equator, all the way, about equi-distant from the equator and the pole, while the other would carry them to the antipodes.

After this, the cars were soon in motion again, and they went on their way. Marco met with no farther mishaps till they reached the end of their journey.

CHAPTER X.

THE BREAKING UP.

ALTHOUGH the snow had nearly disappeared from Connecticut, and even Massachusetts, when Forester and Marco Paul passed through those states on their visit to the armory, yet they found, when they reached Vermont, vast stores of it still remained. The route which they took required them to make a day's journey by land, at last, to reach Mr. Forester's. This day's ride, which they took in the stage, would have carried them home if the travelling had been tolerable ; but the state of the roads, caused by the breaking up of the winter, was such that they went on very slowly.

In some places the wheels of the coach ran along very easily upon the thin stratum of ice which remained upon the road and kept it hard. At other times they ploughed their way along through deep patches of snow, extending for miles,—the remains of the great drifts of the winter ; and sometimes these drifts were so deep that the wheels of the coach would set fast in them. In such cases the passengers would have to get out, and then the driver would urge the horses to draw out the

empty carriage to the land beyond. At other places still, the surface of the ground seemed broken, containing patches of a hard crust, with deep holes filled with soft mud between them. The horses' hoofs would break through in such cases, and sometimes the wheels would sink in, up to the hubs, making it almost impossible to get along at all.

In one such place as this, at the foot of a long hill, the passengers had to get out, in order to make it possible for the horses to go on; and after they were out, and the horses had drawn the coach out of the worst of the slough, they called out to the driver to drive along, saying that they would walk up the hill. There was a bank at the side of the road, where they could walk on the grass all the way up; and, though it rained, they all had umbrellas. They walked two and two, and Marco and Forester walked together.

"Marco," said Forester, after they had commenced making this ascent, "I don't believe you know what makes it so muddy."

"Yes," said Marco; "the rain."

"No," said Forester.

"Then it is the melting of the snow," said Marco.

"No," said Forester.

"What is it, then?" said Marco.

"It is the frost," said Forester. "The frost operates very curiously,—in a manner that few

persons fully understand. I will explain it to you."

"What water there is in the ground, in the fall of the year," continued Forester, "freezes and swells. It of course swells the ground up with it."

"I never knew that before," said Marco.

"Yes," said Forester, "that is the case. You knew that water always expanded in freezing, did n't you?"

"Yes," said Marco.

"And, of course," said Forester, "it causes the ground to swell, unless the ground is composed of sand, or some porous material which enables the water to swell into the pores, without raising the ground itself. In all common soils it swells the land, and raises it."

"How much?" said Marco.

"O, an inch or two," replied Forester; "sometimes more. Did you never observe, where a large stone just peeps out of the ground, that when the ground freezes there is an indentation all around the stone, as if it had settled?"

"Yes," said Marco, "I've seen the stones so in the pasture. I thought they really settled."

"No," said Forester, "they remain as they are; but the land rises, being swollen by the frozen water that is in it. The whole surface of the ground is raised in this way every winter, and then, in the spring, when the ground thaws, it lays up light, all ready for roots to extend themselves

in every direction into it. Thus the frost is the great natural pulverizer of the fields. All summer, in the fields and in the woods, the roots are pushing themselves forth in every direction, and filling up the earth, and the loose particles are washed into the interstices, and men and animals tread it down so that it becomes quite hard ; and then the frost comes in the fall and winter, and swells it all up again, so as to separate the particles of earth from each other a little ; and then, when the water thaws in the spring, it leaves them so, all ready for the roots to take a fresh growth."

"What an excellent plan!" said Marco.

"Yes," said Forester ; "it saves the farmer a vast deal of labor ; but there are some inconveniences that arise from it."

"What are they?" asked Marco.

"Why, there are two principal ones," said Forester. "First, when the ground rises in this manner it lifts up everything upon it ; buildings, fences, and everything else."

"Not the houses," said Marco.

"Yes," said Forester, "if they rest upon it ; that is, upon the upper part of the ground, which is the part lifted. To prevent it, they dig down and lay the foundations upon the lower part of the ground, which remains at rest—because it is so far below the cold air, that the water in it does n't get frozen. But fences cannot well be protected ; for the surface of the earth will freeze around the posts, and thus when it rises, it heaves them up a little

way. The next year they get hove up a little higher, and so, finally, sometimes out of the ground."

"Entirely?" asked Marco.

"Why, so far that they fall over," said Forester. "But the greatest of the inconvenience produced by the swelling of the land, is on the roads. In the spring of the year, when the roads thaw, the water which is in the gravel shrinks in thawing, and leaves the gravel not only wet, but lying loosely as if it had been ploughed and harrowed. This is what makes the roads so soft. It is n't the rain, or the melting snow; for you know, in summer, after a long rain, though the road is as wet as it can be, it is not so soft as it is now."

Forester would have explained the subject more fully to Marco, but they now arrived at the top of the hill, and got into the coach again. They rode on until nearly night, and were then more than twenty miles from home. Now Forester had an uncle who lived in the part of the country where they were passing; and as they were tired, and Forester thought there would be some danger of upsetting in riding in the night, they concluded to stop there and to take the next stage home.

"When will the next stage come along?" asked Marco.

"Day after to-morrow," said Forester. "The stage goes one day and comes the next."

Marco anticipated some pleasure in calling to see this uncle. He lived in a solitary place among

the Green Mountains, upon his farm. Their pleasure was, however, very much marred on their arrival, at learning that their uncle was sick. Forester watched with him that night, and the next morning he was worse. They wanted to send to Mr. Forester to come and see him, as the physician considered him in danger. There was nobody to send but Marco; for Forester was unwilling to leave his uncle, and the family were also very unwilling that he should go. Marco volunteered to take a wagon, and go for his uncle Forester. It was only twenty miles, he said, and he could drive twenty miles very easily. Forester was very much at a loss to know what to do. He was unwilling to send Marco alone, on such an expedition, but there seemed to be no alternative. So the horse was harnessed into a light wagon the next morning, and Marco took his seat in it. Forester wrote a letter to his father, describing the circumstances of his uncle's sickness, and he gave Marco many charges to drive slowly, to walk the horse nearly all the way, and to keep well up on the highest side of the wagon in going over the drifts of snow; and finally, if he got into any difficulty, or found that he could not get along, to stop at any house, and hire a man to go the rest of the way with him.

Marco was very much pleased at being entrusted with so important an enterprise. He went on ten miles without any special hindrance. The road was lonely, conducting him through glens and

forests, and among swamps and streams swelled to overflowing, with the rains and the melted snows. These streams, however, had all bridges, and there were causeways across the swamps, so that he found no difficulty with them until, at last, when he was within about ten miles of home, he came to a place where he saw the water standing in the road, apparently quite deep, for a long distance before him. There were great swamps on each side, which were also full to overflowing, with water, and about at the middle of the inundated part of the road a strong current was setting across the road, with a large cake of ice floating down upon it, exactly in his way.

Marco judged that the water was not very deep, however, in the road, from the height at which it stood at an old brush fence which extended along on one side of the road. While he was hesitating, however, what to do, he saw a pedestrian traveller advancing along the road, on the other side of the water. He had a bundle on his back. He stopped, like Marco, as soon as he reached the water.

Marco called out to him, in a loud voice, "Can I come along through this water?"

"I don't know," said the man; "I suppose so."

Marco hesitated a moment in doubt. He perceived that the water could not be very deep; so that if he should fall in, he would only get a wetting. Then that man was there, ready to come to his aid if any accident should happen. Besides,

he could not turn round very well, where he was, to get back again, even if he had wished to turn back; so he boldly pushed on. The horse waded along the road, the wagon following him, and tipping to one side or to the other, according to the inequalities of the snow and ice which yet remained under the water on the track. When he got to the middle, he had to wait a minute or two for a cake of ice to float by, and then he went on, and the horse soon came out upon the firm ground—his limbs dripping with the water.

The traveller then wanted Marco to turn round and carry him across the water, and offered to pay him well for it if he would. But Marco did not see how he could turn safely; so he declined this proposition, advising the man to clamber along as well as he could on the brush fence. Marco sat in the wagon looking back for a few minutes, laughing at the comical figure which the man made, with his bundle on his back, clambering along on this unusual sort of bridge. He said to himself that the man looked like a hump-backed monkey climbing trees. After he saw that the man got safely over, he rode on.

He however soon encountered a more serious difficulty than this. He came to a large pond. The road passed around the end of it. A large stream issued from the pond at this place, and the road had crossed this stream just by the edge of the pond, on a bridge. The water was, however, so

high, that the bridge was not in sight; but Marco supposed it was there, and that he could ride over it, through the water. There was a small house on the edge of the woods, a short distance back, and just as Marco was going to drive forward, a man came out from behind some piles of lumber near it, and called out to Marco, telling him that the bridge had been carried away.

“Then how shall I get across?” said Marco.

“You can’t get across at all,” said the man.

“But I *must* go,” said Marco.

“Well,” said the man, “if you must go, and can’t go, I don’t know how you’ll settle it.” So saying, he turned around and disappeared.

Marco got out of the wagon, fastened the horse, and went back to the house. The man was at work under a shed, making a cart-body. He kept on with his work, but in answer to Marco’s questions, he told him that it was impossible to get across there till the water went down, and the bridge was repaired; and that there was no road by which he could go around the difficulty, except by a circuit of fifteen miles. Marco sat down upon a log lying in the yard, in a state of great perplexity. After some minutes, he looked up, and said,

“Could you work for me, sir?”

“Work for you?” repeated the man.

“Yes,” said Marco. “I will pay you for it at the rate of a dollar a day.” Marco had heard that this was pretty high wages for that part of the country at that time.

“I don’t believe you have got any money,” said the man.

“Yes,” said Marco; and so saying he took out one half a dollar from his pocket, and showed it to the man.

“What do you want me to do?”

“To help me build a raft, to raft my horse and wagon over this water.”

“O, you can’t raft them over,” said the man.

“Yes,” said Marco, “you must fell me some small trees, and cut them into lengths, and roll them into the water. Then I shall want to buy some of your boards to cover it with.”

“O, no,” said the man; “we could not make a raft in that way big enough to float your horse and wagon.”

“No,” said Marco, “but we could raft the horse over first, and then the wagon.”

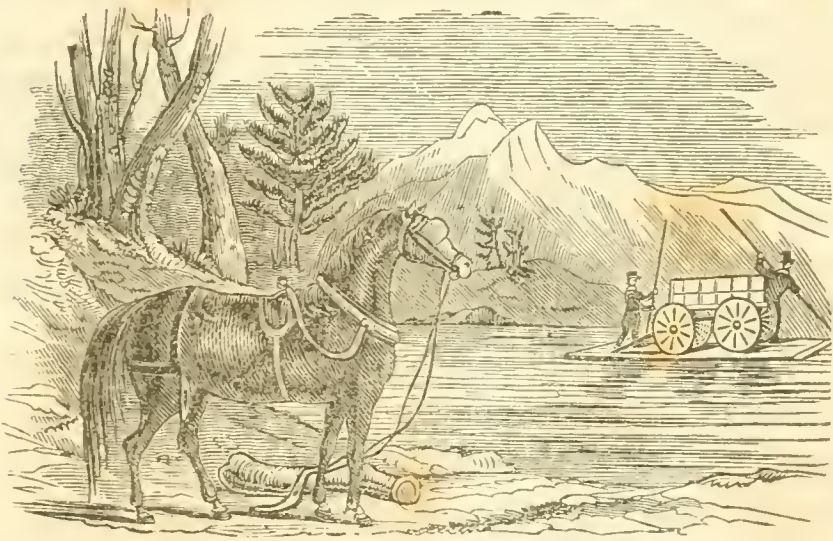
“Well,” said the man, “I’ll try it for half a dollar.”

“No,” said Marco; “I’ll pay you at the rate of a dollar a day for the time it takes.”

“Very well,” said the man, “any way to suit you. I don’t know but that you will get over.”

So the man went with Marco down to the shore of the pond, and began to cut down some trees. He told Marco which were the lightest and most suitable, and when about twelve of the lengths had been prepared, he and Marco rolled them into the water, and placed a board across them to hold them together. The man then walked out upon

the board, and with an auger bored holes down through it into the logs, and pinned it down. There was one pin driven into each log. Several other boards were placed alongside of the first, until the raft was floored over. The man then cut a long pole to push with. They were going to push the raft across at the end of the pond, just above where the outlet issued from it. They led



the horse carefully on to the raft, and Marco held him while the man pushed over. They accomplished the passage safely, and then came back for the wagon. The transportation of the wagon was effected without difficulty, and the horse harnessed into it again, and Marco was once more able to proceed. The man estimated his work at one fourth of a day, and the boards and logs he considered to be worth twenty-five cents. So Marco paid him half a dollar, and was just going to get

into his wagon, when the stage appeared in sight, coming towards him. "Now," said Marco, "I'll sell my raft to the driver of this stage."

When the driver saw the condition of the road he exclaimed,

"What! is this bridge carried away?"

"Yes," said the man, "it went off last night."

"And how then am I to get over?"

"I don't know," said Marco, "unless you buy my raft."

"Your raft?" said the driver, "is that your raft?"

"Yes," said Marco, "I've just paid for it, labor and materials. It has cost me half a dollar, besides all the planning of it. You may have it for the same."

The driver looked at the raft a moment, with a smile on his countenance, and then said, "But I need not pay you for it. There the raft is. I've only to take it and use it, if I've a mind to."

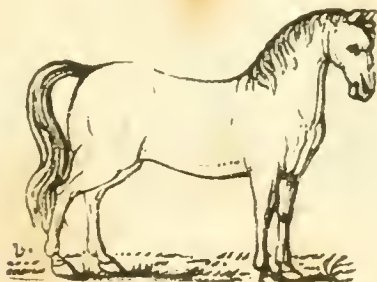
"But I forbid you to use it," said Marco, "unless you pay me for it."

"What good will your forbidding do?" said the driver. "I happen to be the strongest."

"O, yes," said Marco; "you can rob me of it, I know. If I am so unlucky as to get robbed here in this solitary place, I suppose I must submit to it; that's all."

The driver did not quite like this aspect of the subject, and besides, his passengers began to put their heads out of the windows of the coach, and

told him that he had better buy the raft. So he gave Marco half a dollar, saying, at the same time, that it would cost him one quarter of a dollar more to make it big enough to float his stage-coach; but even that he admitted would be better than to go fifteen miles around. Thus Marco got across the water without any other inconvenience than the delay. He arrived home safely. His uncle Forester returned next day in the wagon to see his sick brother. He crossed on the raft. He found his brother better, and on the third day he and Forester returned in the stage,—but by this time the bridge had been repaired.











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